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AN INTERESTING PUMPING ENGINE.

There has recently been completed in the shops of the Allis-Chalmers Company one of the most interesting pumping engines ever built. In point of power it practically equals the largest, that constructed by the same firm for the city of Nashville.

The new engine is for the city of Wheeling, W. Va., and is of the vertical triple expansion crank and flywheel type with steam cylinders 42 inches, 74 inches, and 110 inches in diameter and water plungers 33 inches in diameter. The low pressure cylinder is the largest cylinder ever used on a pumping engine. The cylinders are all steam jacketed, and the steam for the use of the jacket of the high pressure cylinder is bypassed around the admission valve. That for the intermediate and the low pressure cylinders is taken from the first and the second receivers respectively, and that from the jackets of the high pressure and intermediate cylinders is trapped into the second receiver and does useful work in the low pressure cylinder.

Admission valves on the high and the intermediate cylinders and the exhaust valve of the high pressure cylinder are of the Corliss type, while the exhaust of the intermediate and both admission and exhaust of the low pressure cylinder are of the poppet type. The valves are driven from eccentrics on a lay shaft supported on brackets on the main frame of the engine. This lay shaft is driven by drag cranks and connecting rods from each end of the main shaft.

The engine is designed for a steam pressure of 125 pounds and a vacuum of 27 inches. The stroke is 72 inches, and at the regular speed of 18 1/3 revolutions per minute the piston speed will be 220 feet per minute. Two fly-wheels each weighing 90,000 pounds are provided. The condenser is of the surface type and is located in a by-pass of the discharge line of the pump with cut-off valves on either side. The engine is provided with a free exhaust for use when necessary. The condenser pump is driven from an arm on the low pressure plunger.

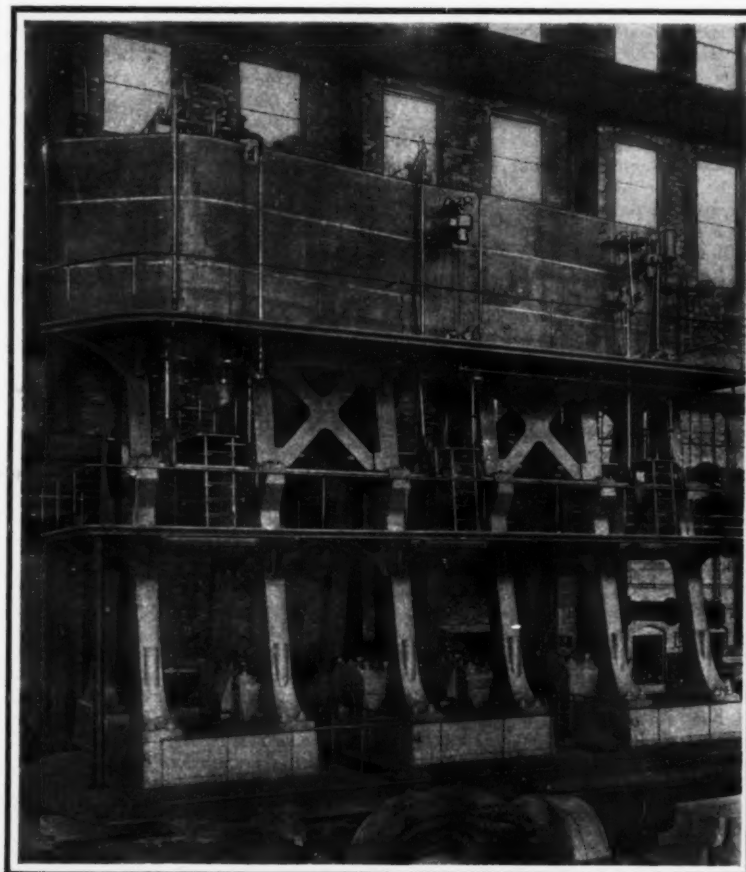
The valve chambers are 78 inches in diameter, which are the largest ever built, and are of cast steel. The pressure chambers are also of cast steel. The valve deck is steel and the 186 valves in each chamber are placed directly in the deck without the use of cages. The valves are of a special weighted type, which obviates the need of springs.

The water end of the pumping engine is self-contained and self-supporting. The steam cylinders are supported on double A frames, one end of which rests on the water ends and the other on a pier. The pit in which the water end is located is 46 feet deep, and the total height of the engine from base of water end to top of steam end is 84 feet 8 inches.

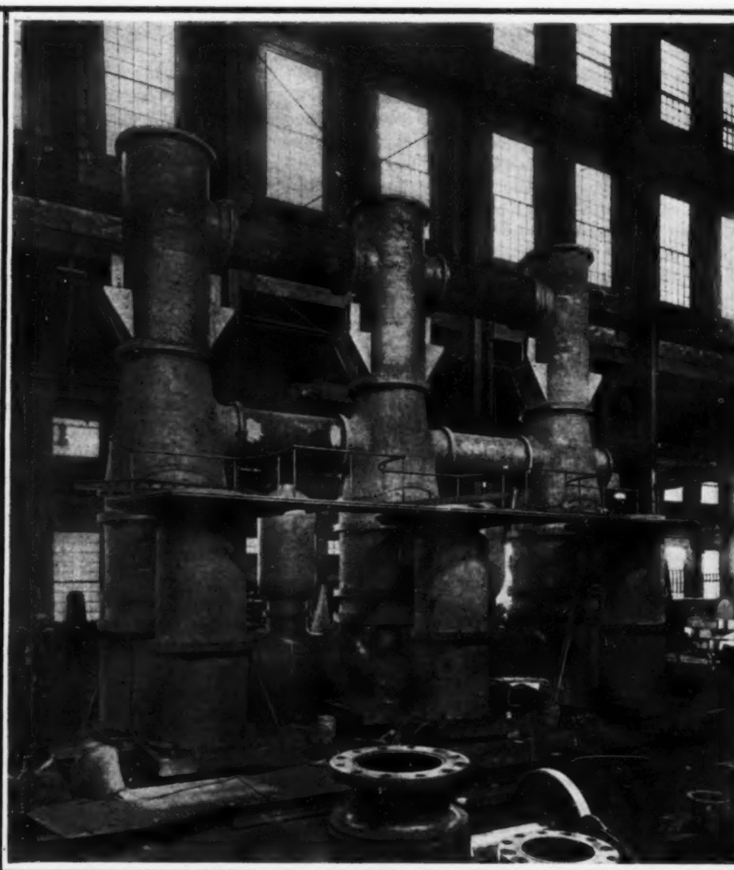
Each piston has a single piston rod which connects with a cast steel cross head into which it is screwed and held by a lock nut. Four steel distance rods connect the steam cross head with the water cross head, which is of cast steel. This is connected to the water plunger by means of heavy cast iron pipe sections fitted with adjustable guides.

Galleries are provided at the level of the valve deck and at the plunger chambers in the pit. Above the engine room floor are two main galleries. The lower gives access to the crossheads, eccentrics, etc., while the upper allows inspection of the valve gear and permits the use of the indicator motion. The tops of the cylinders are connected by platforms for reaching the upper poppet valves.

The accompanying illustrations show the general character of the engine as completed in the West Allis Works of the Allis-Chalmers Company.



STEAM END OF VERTICAL TRIPLE-EXPANSION PUMPING ENGINE BUILT FOR THE CITY OF WHEELING, W. VA.



PUMP END OF VERTICAL TRIPLE-EXPANSION PUMPING ENGINE. CAPACITY 20,000,000 GALLONS DAILY.

AN INTERESTING PUMPING ENGINE.

SIR OLIVER LODGE ON ELECTRICITY AND AGRICULTURE.

Sir Oliver Lodge, lecturing at the Midland Institute, Birmingham, on "The Electrification of Crops," said the discoveries of Pasteur with regard to the action of micro-organisms had a bearing not only upon medical practice and the theory of disease, but likewise upon agricultural practice and the theory of manuring. A multitude of facts were now coming to the front which explained old practices and suggested new ones, so that the farm became a laboratory of great importance, and life in the country, so far from being dull, was full of absorbing interest.

Of the problems which were receiving and yet waiting attention, the absorption of nitrogen by plant life was surely one of the chief. The action of nitrifying bacteria in the soil, the influence and functions of leguminous plants in the rotation of crops, the whole process of the absorption, elaboration, and assimilation of sap, the chemical changes going on in the laboratories of the leaf under the influence of sunshine, and the discharge of electricity from plant surfaces under the action of ultra-violet light—all these had been recognized for a few years, though as yet they were imperfectly studied. But others of perhaps equal importance were coming to the front, and in combination with those he had mentioned they would powerfully affect the power of the British nation to feed itself and to lessen the extremely large amount of imported food. In time of war this power to feed ourselves might become crucial and essential to our existence. In time of peace it would mean a great

economy and a great liberation of national funds for other purposes, since what was grown out of the soil was clear profit, and the larger area we got under cultivation the wealthier in every wholesome respect the nation would become.

Discoveries lay before us in the direction of the reclamation of barren soils, the influence of strong sunshine, and of heat upon soil in preparing it for seed, and now in the curious effect not only of burning, but of poisoning or disinfecting the soil, and thereby increasing its fertility. This last process had come to be understood now as having the effect of destroying opponents or devourers of the useful and co-operating bacteria. These opponents were more easily slain than the useful bacteria, and when they were killed the bacteria increased and multiplied to a prodigious extent, and the soil became far more fertile than before. In addition to this there was the problem of the electrification of the air above the growing plant. Such electrification always existed, and the pointed character of the leaves showed that it was made use of; but by artificial means it could be intensified, the plant stimulated, and the action of feeble sunshine accelerated and assisted by high tension electricity, purposely conveyed to the atmosphere above the plant. Work in this direction had been done in Sweden by Lemstrom, and in France by Berthelot. But the means available for electrification were imperfect and feeble. Only recently had they been able to supply electricity of the amount desired in a fairly easy and permanent manner, so that when Mr. Newman and Mr. Bomford wished to try experiments on a large scale in the neighborhood of Evesham he (Sir Oliver) was able to assist them with the proper apparatus and the mode of producing electricity. With the aid of slides Sir Oliver showed how the electricity promoted the growth of plant life, and added that an agricultural electrical discharge company had been founded, which had sent out apparatus to Germany, Austria, Java, Sweden, and to Scotland for experiments. Mr. Lowe at Balmakewan was testing the whole process scientifically and financially for five years. Dr. Priestly, of Bristol, a scientific chemist and botanist, was also giving careful attention to the testing of results.—English Mechanic and World of Science.

THE OIL ENGINE ON SHIPBOARD.*

A NEW STEP IN MARINE ENGINEERING.

If anything were required to emphasize the rapidly increasing attention that is being shown in marine engineering circles toward the growing possibilities of the oil engine for ship propulsion it is the importance attached to the question in the report of the committee of Lloyd's registry for 1909. Probably the recent publication of the fact that the Hamburg-American Company had placed an order with Messrs. Blohm and Voss for a 9,000-ton liner, which it was proposed to propel with Diesel engines, had a good deal to do with stimulating inquiries as to what could be done in this direction, but some of the more progressive naval constructors have been keenly interested in oil-driven engines for a long time. The principal reason for this may be found in the extraordinarily rapid development of the gasoline motor for cars and boats, and more latterly for aeroplanes, wherein, of all machinery, the weight per horse-power requires to be a minimum, while to some extent it may also be partly attributed to a better appreciation of the work that has actually been done by submarine boats, and a fuller realization of the sizes in which their engines are being made.

The earlier attempts at applying internal combustion engines to boats were on a very small scale, and the type of motor adopted was practically identical with that used on land; that is to say, it was a four-cycle single-acting gasoline engine wherein reversibility was obtained by the use of clutches, or by firing a charge on the top of an upcoming piston after the gaseous mixture had been cut off from the other cylinders. Obviously the former system becomes impracticable at outputs above about 400 brake horse-power, and the reversibility of the engine itself must really be regarded as a *sine qua non* for marine purposes. The most important use of gasoline engines for ships has hitherto been for submarine work, the first British boat of this kind being passed into the Royal Navy as long ago as 1902. She was fitted with a four-cylinder gasoline engine of 160 brake horse-power running at 340 revolutions per minute, but in the following vessels of the A class the motor was of the twelve-cylinder type, made by the Wolseley Company and developed about 600 brake horse-power when running on the surface. In the B and C classes of submarine the engine power and number of cylinders were considerably increased, while in the D class boats the combined power on the two shafts is rather over 1,200 brake horse-power. The use of gasoline in such confined spaces as are found in submarines is fraught with many dangers and difficulties, and great credit is due to the naval staffs who are responsible for their maintenance that accidents due to explosion have been of such rare occurrence. In some of the boats experiments have been made in running the engines with heavy oil, and a large measure of success has been achieved; so much so, in fact, that oil engines alone are now used for British boats. The same applies to both French and German submarines, all the more recent boats both in these and the British service being propelled by engines of the Diesel type.

It is a curious fact that after the proved success of gasoline engines on land, nearly all the earlier designs for vessels to be propelled by internal combustion engines should have embodied gas-producers, and that the intention should have been to use producer-gas as the primary fuel, and not oil, although it has long been recognized that, granted a suitable type of engine, the two are really interchangeable. The prominence given to schemes for introducing gas engines into ships has undoubtedly distracted a considerable amount of attention from the use of oil. The suitability of the type of fuel is naturally one of the leading questions that must be determined, but it must be also reckoned with as weight. A good producer gas engine will require at least twice the weight of fuel needed for the best oil engine of corresponding power; one type of fuel, however, may be more readily or cheaply obtainable. If oil is to be used, what is the best system on which to use it? It is the correct answer to this question that is now vexing the minds of marine engineers.

Two general types of engine are available—the four-cycle and the two-cycle; these may be subdivided into single and double acting engines. Again, what is the system of ignition to be? Two forms of engine are available—one of the usual, the other of the Diesel type. It must be confessed at once that there is as yet insufficient experience available to determine this matter; probably no one type will be generally applicable. But it remains to be seen whether any type at all will find an assured place among propelling systems, or if oil engines will only be adopted for subsidiary harbor services, such as electric lighting or auxiliary use in steamboats. The wide application to marine propulsion that seems to be expected in some quarters must certainly be described as a dream of the future, and must remain so till one or two initial installations have been proved adequately reliable and commercially possible. Marine work differs from all land work; a complete breakdown in the engine room does not merely cause a tram car stoppage, or the temporary suspension of electric light such as would result from a similar accident in a power station, but it also involves risk to the lives of crews and passengers, or to many thousands of pounds worth of freight. Reliability is the primary consideration. It must be remembered, too, that a ship requires machinery for many other purposes than propulsion. Practically 20 per cent of all the boiler power goes to feed the numerous and generally uneconomical auxiliary engines. Electric light must be provided; steering gear, bilge, ballast and sanitary pumps, turret turning engines and winches, capstans, fans, and a score of other small machines must be driven. Let us begin by small steps. In the experience in the Royal and foreign navies of the use of oil engines for driving dynamos, it has certainly proved a partial success in units of 200 brake horse-power, but that success is only partial, and breakdowns have frequently occurred. Again, the record of the submarines is better, but imperative secrecy shrouds both their failures and successes, and in their case general suitability enforces the adoption of an oil engine, while, moreover, there are no auxiliaries of any moment. The past history of important improvements in marine propulsion deserves reflection; the case of the triple-expansion engine and the turbine, each of which took years to introduce, should not be forgotten. Much more recently it was strikingly evidenced by the service performances of the Otaki and Vespasian what economies could be effected over the usual tramp propelling machinery, but even with this incontrovertible evidence builders and owners have been extraordinarily slow in adopting the proved improvements. It is impossible to imagine that the oil engine will have better luck and wider adoption until its economies are also shown to be more than paper calculations. For small steamers—river boats, smacks, drifters, and so on, it is already making progress, as the exhibition at Yarmouth shows. In their case the power is low, but if we take the case of a 3,000 horse-power cargo boat, we find the immediate problem to be solved is what type of oil engine to adopt. To what ships can one turn for comparative information, or what is the largest unit yet made? It must be confessed that the status of the oil engine in marine work is somewhat embryonic; those who have studied what has been done at sea as well as the land status of the engine may have a few views, but it is curious what a striking divergence of opinion there is. In the recent adoption of Diesel engines on the Continent we find three different types of engine—single-acting four-cycle, single-acting two-cycle, and two-cycle double-acting. In these cases the engine itself is reversible; in its earlier forms the screw was reversed by clutches, or some electrical system was adopted, neither of which can be accepted as a permanent solution of the difficulty. If, however, the type of engine is settled, the extent to which it will be adopted is the next consideration. Obviously, for safety, it would be better to begin by installing, say, twin screws of 1,000 horse-power each, rather than one unit of 2,000 horse-power; but then the weight and initial cost begin to rise. Elaborate cooling is necessary, which involves special pumping plant. Forced lubrication—never found in tramp steamers—is practically essential. Oil engines in place of the main steam engine will not obviate boilers. A large auxiliary boiler must be retained, and consequently an auxiliary condenser becomes necessary, whereas in a steam set the one main condenser would suffice. By the time that the whole installation is arranged to the satisfaction of the superintendent engineer responsible for producing results from it, it is doubtful if there will really be very much saving of weight, except in fuel carried for a given radius. For gas-driven ships this will not be greatly reduced, but a Diesel engine should not need more than 0.5 pound per brake horse-power, which materially reduces the requisite weight of fuel, and in itself represents a great gain in economy in those regions where oil fuel can be obtained. This latter is a point of paramount importance.

Granted that some form of oil engine is to be adopted, there are many mechanical points that need very thorough attention before any serious progress will be made. The statements made about battleships and cruisers being fitted with internal combustion engines may for the time be dismissed as absurd. The largest marine oil motor at work is a submarine engine of 800 brake horse-power; larger engines have been built abroad, but are not on board a ship. The limit of size is found in the power that it is possible to produce in one cylinder; up to the present this has not exceeded about 500 brake horse-power, though 1,000 horse-power cylinder units are now being made on the Continent. Until material advances can be made on this, oil engines for high powered craft would seem to belong to the distant future, and to be more suitable for the slower cargo vessel of 2,000 to 5,000 horse-power, wherein weight is of less vital importance. Why, however, ships' boats are not driven by internal combustion engines is not easy to understand. The 50-foot picquet boat in the Navy is still driven by a water-tube boiler and small triple engine; abroad, the motor boat for ship work is generally accepted. Uncertainty of fuel supply abroad is the only reason that can be alleged against the introduction of such engines, and does not seem to be an adequate one.

* The Engineer.

Wire cables for holding shaft timbers are used at the Fremont mine near Amador City, Cal. The shaft has two compartments, dips at an angle of 52 deg., and is 650 feet deep with a 50-foot sump. In sinking this shaft some heavy ground that caved badly was encountered. The Engineering and Mining Journal states that it was impossible to get a bearing for the wall plates or caps, and the more the ground was trimmed away to secure a bearing for these timbers the worse it caved, until a large cavern was formed above the shaft. In order to timber the shaft through this ground, the expedient of securing the timbers in place with old hoisting cable was tried and proved quite successful. The sets in the caving zone were tied with the cable to those above which had firm bearings in the wall rock. This hanging of the timbers was continued until firm ground giving sufficient bearing for the timbers was again encountered. Stringers were then placed over the suspended shaft sets and upon them a cribbing was built.

THE METAL LAMP FILAMENT.

ITS MANUFACTURE.

BY DR. H. F. BAUMHAUER.

The manufacture of electric incandescent lamps occupies an important place in modern industry, and patents are issued almost daily for new processes and improvements of chemical or technical character. There are some German factories, each of which produces about 50,000 lamps daily.

Before the middle of the last century endeavors were made to utilize for illumination metal wires heated to incandescence by the electric current, but these experiments brought forth no practical result, as the melting points of the metals employed were too low to allow the attainment of temperatures of intense light emission. Even platinum, with which Edison experimented for a long time, proved unsatisfactory, although its melting point is about 3,100 deg. F. The high price of platinum presents another insuperable obstacle to its practical employment.

A great advance was made by the introduction of the idea of employing filaments of carbon, which possesses over platinum, in addition to cheapness, the great advantages of very high specific resistance (more than 100 ohms), permanence and infusibility; but many years elapsed before the carbon filament was developed to its present form, and countless experiments and observations were required to show what properties a good carbon filament must possess, and by what methods it can be produced. The first filaments were made of gas-retort carbon, a very pure and dense form of carbon which is produced, for example, by passing acetylene or other hydro-carbons through a red-hot tube. The hydro-carbon is decomposed and the carbon is deposited in a form resembling graphite upon the wall of the tube. This gas-retort carbon was cut into thin slices and then into filaments. This method of production, however, presented great difficulties, and it was almost impossible to make filaments of uniform thickness, so that the method was not suitable for practical use. Edison then invented the method by which comparatively homogeneous and durable carbon filaments were first produced. He employed bamboo, separating from the pithy matter long flexible fibers, which were then carbonized by heating them to a high temperature out of contact with air. In this way it is possible to expel all the volatile constituents of the fibers, leaving behind a fairly homogeneous filament of carbon. This invention of Edison's stimulated other workers to experiment with fibers of other plants and trees, straw, silk and even hair, for the production of lamp filaments. A very interesting method was developed by Swan, who utilized the property of concentrated sulphuric acid to convert cotton into a substance resembling parchment. Loosely spun cotton yarn was drawn through sulphuric acid of a definite high concentration. The cotton fibers, which almost instantaneously became gelatinous, were freed from sulphuric acid by repeated washing with water and were then dried. In this condition the filaments are very strong, and it is very difficult to break them. They are then carbonized.

None of these methods, however, proved satisfactory. Either the method was too complex and tedious or the filaments were not sufficiently uniform in thickness and electrical resistance. The result of this defect is an unequal heating of the filament at different points of its length, and a great shortening of the life of the lamp. The newest method, which is now employed in almost all electric lamp factories, has practically overcome all of these difficulties, and very satisfactory carbon filaments are now produced by comparatively simple processes.

The fundamental principle of the production of carbon filaments is approximately the same in all factories, although each has its variations of detail, suggested by experience, which are kept strictly secret. This principle is the same as that of the production of artificial silk. Guncotton or ordinary cotton wool is dissolved in an appropriate solvent, and the thick solution is expelled by pressure through small orifices into a vessel containing a liquid which immediately coagulates and hardens the issuing jets of dissolved cotton, or guncotton, into filaments having the diameter of the orifices. For example, guncotton is dissolved in glacial acetic acid and coagulated in water. The solvent employed for ordinary cotton is Schweitzer's liquid, an ammoniacal solution of cupric oxide, and the mass is coagulated by injection into dilute acids.

The production of lamp filaments from guncotton will now be described with a little more detail. It is very essential in this process to start with pure raw materials. The guncotton (nitrated cellulose) must leave very little ash on burning. The excellence of the filament is also largely dependent upon the rapidity of coagulation, which is increased by the addition of sodium carbonate to the mass. Another very important operation is the thorough washing of the gelatinous filaments, as any trace of acetic acid or its salts would exert an injurious effect in the subsequent process of denitration, by which the nitro groups (NO_2) are removed from the cotton. This denitration is effected by prolonged treatment with ammonium sulphite. The filaments are then ready for the carbonizing process. In order to obtain the carbonized filaments directly in the form required for use in the lamps, the filaments are wound upon forms, usually made of retort carbon, before they are placed in the carbonizing oven. In order to exclude air the forms are imbedded in pulverized charcoal, or graphite, in vessels of fireclay, which are then slowly heated by a gas blast gradually to 3,100 deg. F. After the carbonized filaments have cooled they are heated by passing an electric current through them, to a very high temperature (3,600 deg. F.) in an atmosphere of gasoline vapor. By this operation the last traces of volatile matter are driven off and the filaments become coated with a uniform deposit of graphic carbon, which increases their strength and flexibility.

This brief description of the general method of producing carbon filaments shows how difficult it was to reach the really good results which are now obtained. A good carbon filament must be perfectly homogeneous and of equal section and electrical resistance at every point. In the second place, the filament must have been converted almost entirely into graphite by carbonization at a high temperature and subsequent heating in an atmosphere of gasoline. The graphitic character of the filament is of especial importance because it prevents rapid blackening of the glass bulb, and thus prolongs the life of the lamp.

No sooner had the carbon filament been perfected than it was exposed to the competition of rivals. The carbon filament lamp, despite its many advantages, could not compete in economy with the incandescent gas lamp. Strenuous attempts were therefore made to devise electric lamps using less candle power. For this purpose recourse was again had to metals of high fusing point, but the most suitable metals, having fusing points between 3,600 and 5,400 deg. F., are so brittle that thin filaments cannot be made from them by the usual process of wire-drawing. Of those metals whose fusing points fit them for use in electric lamps, tantalum, which melts at 4,350 deg. F., is the only one from which sufficiently fine wires have been directly drawn. Siemens & Halske long offered electric lamps with drawn tantalum filaments. Of all metals, however, tungsten is most suitable, because of its very high melting point which is estimated at 5,075 deg. F. It is not possible to measure this point accurately, as no satisfactory method of fusing tungsten is known. Weiss has recently described experiments in which he attempted to fuse by the passage of a powerful electric current electrodes made by compressing pulverized tungsten. The result was not very satisfactory. By this method, however, Weiss succeeded in fusing titanium and zirconium, and calculating their fusing points from the electrical energy consumed. The fusing points were found too low to make these metals suitable for electric filaments. Great expectations had been entertained of titanium, for which a very high fusing point had been inferred from its general chemical and physical properties.

Although it has not yet been found possible to make tungsten filaments by drawing, such filaments are made by other methods. For a long time the filaments of the Just lamp were made by exposing carbon filaments to the vapor of tungsten compounds, the chloride for instance, which was deposited as a coating upon the carbon. The filament was then heated carefully in hydrogen, which removed the carbon and reduced the tungsten to the metallic state, so that a fine, hollow filament of tungsten was produced. This method, however, was so complex, and produced filaments so weak that it was soon abandoned.

The modern processes start with metallic tungsten, which must be very nearly pure, as even a slight impurity makes the filament useless. Pure tungsten can be produced without difficulty by mixing the oxide with pulverized zinc, and heating the mixture in a closed iron crucible by a gas blast for about eight minutes, when a reaction suddenly takes place and the tungsten is reduced. The crucible is then set to cool in an iron vessel from which the air can be exhausted.

The zinc and zinc oxide which are mixed with the tungsten are dissolved out by hydrochloric acid, leaving the tungsten in the form of a fine amorphous black powder. By the addition of a suitable binder this power can be converted into a plastic mass from which filaments can be pressed. The binder must be of such composition that it can be entirely removed by burning or evaporation. Gum tragacanth, caramel, and other forms of sugar and gum, with the addition of a little glycerine or castor oil, are the binders commonly used. The metal is rubbed up with a concentrated solution of the binder until a very stiff paste is produced. The filaments are formed by forcing this paste by a pressure of 20 to 30 atmospheres through minute orifices in diamonds. The smallest of the orifices, used for the production used of 16 candle-power filaments, are about 1/500 inch in diameter. The filaments are dried and heated to about 2,000 deg. F. in hydrogen, by which operation the binder is burned out and the filament is sintered, so that its diameter is diminished nearly one-third. It is now necessary to consolidate the filament by heating it to whiteness by an electric current in an inert gas, such as hydrogen or ammonia.

There is, however, a newer and much simpler and more elegant method of producing tungsten filaments. By appropriate methods metallic tungsten can be obtained in the form of a powder so fine that it forms with water a transparent brown colloidal solution, in which the individual metallic particles cannot be seen with the eye or with the ordinary microscope, but can be detected only by the ultra-microscope. Many other metals form similar colloidal solutions of characteristic colors. The colloidal solution of gold, is deep ruby red.

By Dr. Kuzel's method amorphous tungsten powder is brought into the form of a colloidal solution by treating it alternately with acids and alkalies. The colloidal solution thus obtained is very concentrated, containing four parts by weight of tungsten to ten parts of water.

Colloidal solutions can be precipitated by the addition of electrolytes. The best precipitant for tungsten is ammonium chloride, which precipitates one thousand times its own weight of tungsten, in the form of large flakes. The clear liquid is poured off and the flocculent voluminous precipitate is deprived of most of its adhering water by kneading it in a silk bag until it forms a paste from which filaments can be pressed without the addition of any binder. These filaments when dry are comparatively strong and can be metallized or consolidated by the passage of an electric current. By this method the Sirius or Colloid lamps are produced. These are the only metallic filaments that are made without the use of a binder.

Many other metallic filaments have been tried, but the tungsten filament has maintained its supremacy almost unchallenged. The Osmium zirconium and other metallic filament lamps have practically disappeared.

Many patents have been taken out for methods of increasing the luminosity of carbon filaments by the addition of various substances; but none of these methods has yet produced practical results. By most of these processes it is possible to produce filaments which show a low consumption of energy per candle-power at the beginning, but the efficiency soon falls to its normal value for the simple carbon filament. The life of these treated filaments is also short. The substances added are chiefly the metals and oxides of the rare earths. Carbon filaments are also impregnated with calcium chloride and magnesium chloride. Finally, attempts have been made to add to the solution of colloidon in acetic acid, before it is spun into filaments, such substances as the oxides of barium and zirconium, and, for a time, a lamp appeared in the market having a carbon filament covered with zirconium; but none of these experiments has led to any useful results and the field was soon narrowed to the simple carbon and tungsten filaments.

The mounting of the carbon filament is a comparatively simple matter. The ends of the filament are cemented to nickel wires which, at the base of the lamp, are connected with platinum wires fused through the glass. Platinum is used for this purpose because, of all metals, its coefficient of expansion is

most nearly equal to that of glass. The mounting of metallic filaments is a more complex matter. The filament requires supports without which it would bend when heated by the current. These supports are rings of nickel attached to a glass rod. In very powerful lamps hooks of platinum are employed and, very recently, molybdenum wires have been substituted for the more expensive platinum. The connecting wires, as in the carbon filament lamp, are made of nickel and platinum, and the metallic filaments are fused to the ends of the nickel wires by the production of a small electric arc between the two. Nickel is especially well suited for this purpose as it readily forms alloys with tungsten. In metallic filament lamps the thorough exhaustion of the bulb is especially important. A lamp which is not sufficiently exhausted soon becomes black. The same result is produced by filaments which are not thoroughly formed or consolidated.—Translated for Scientific American Supplement from Zeitschrift fuer Angewandte Chemie.

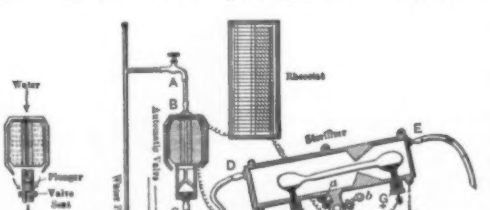
THE STERILIZING ULTRA-VIOLET RAY.

A NEW PRINCIPLE IN SANITATION.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

It will be remembered that Drs. Courmont and Nogier showed that water can be completely sterilized by the action of ultra-violet rays given off by a quartz mercury vapor lamp, and the first account of their researches was presented to the Academie des Sciences last year. Since then, their results have been confirmed at the laboratory of the Seine Prefecture by Dr. Miquel, and all kinds of microbes, even the spore microbes which are so difficult to destroy, are shown to succumb to the effects of the rays. In the first experiments made by the authors, the lamp was immersed in a tank containing water, about twenty-five gallons, and all the usual microbes found in water, such as the coli bacillus and Eberth bacillus, were destroyed in one or two minutes. This experiment proved conclusively that the microbes can be destroyed in the cold and in great quantities in drinking water. In order to find out whether such water could be used for drinking without danger, they made experiments for several months, and submitted plants and animals to the action of such water exclusively. The tests proved that the water was entirely harmless in all these cases, so that nothing prevented the application of the new method for practical use.

The first water sterilizing apparatus which has been brought out by Dr. Nogier at Paris is shown in our engravings, and his object was to design a sterilizer which could be used for domestic purposes. To this end it must be of simple and substantial make and at the same time not likely to get out of order. Its action is quite automatic, and it will deliver sterilized water at the rate of 250 gallons per minute, which is sufficient for most ordinary uses. The present apparatus has three essential parts, namely, the mercury vapor lamp, the cylindrical case, and the automatic valve which works by electro-magnetic action. The mercury vapor lamp with quartz tube has a special form so as to adapt it for use in the sterilizer. After experiment, it was found best to place the electrodes at the under side of the lamp, as in this position they are always covered by the mercury, which prevents any heating or entering of the air, so that we are assured of a perfect vacuum. Direct current is used for the lamp, and this can be furnished by the city mains, using a rheostat to cut down from 100 or 120 to 30 volts, as the lamp is designed to work on this latter current. The cylinder which holds the lamp is of light metal and is made of small size. In order to carry out the sterilization of the water properly, the cylinder is divided into two chambers, as will be observed. The chambers are of different size, with the larger one lying next the water inlet. In the large chamber the water begins to be sterilized and in the second the operation is completed. A diaphragm properly designed forces all the water to pass against the surface of



PLAN OF INSTALLATION OF STERILIZING APPARATUS.

the lamp. Hydrodynamics show that the liquid stream flowing from an orifice of this kind will undergo a contraction at some distance from the orifice itself and that the contracted section is 62/100 of the section at the orifice. This disposition gives the proper play of the water around the mercury lamp, so that the sterilizing can be carried out with a rapid rate of flow and without stopping the stream. A glass-covered sight hole shows when the lamp is lighted.

It is of great advantage to be perfectly sure that the sterilization is always carried out and that in case the current should fail, that no water could pass through the apparatus. An automatic valve is almost a necessity in connection with such a device, as otherwise it would need to be watched constantly in order to be sure that the water was pure. Any uncertainty as to this would make the use of the sterilizer almost

THE NOGIER AUTOMATIC APPARATUS FOR STERILIZING WATER BY ULTRA-VIOLET RAYS.

impossible. However, such an automatic valve can be very readily made by using an electromagnet working upon the same circuit as the lamp, and its armature acts as a valve in order to control the water flow. The whole is inclosed in a tight case and is coupled to the water faucet by a rubber hose. Turning on the current by a wall button causes the current to pass in the lamp and at the same time in the solenoid which surrounds an iron core. The water flows through a central opening and also through holes in the lower movable iron plunger. The lower end of the plunger rests upon the valve seat so that when the magnet lifts it, the valve is open and the water flows through the rubber tube to the sterilizer. Should the current fail, the plunger drops and stops the flow, and this is the same when we turn off the current, so that there are only two operations, turning on the current and tilting the mercury lamp in the usual way by means of two chains, the cylinder being pivoted at the middle for this purpose. By the use of the valve, it is impossible to have non-sterilized water. The present apparatus is designed in the first place for domestic supply, then for various industrial uses where sterilized water is needed, such as for breweries, milk and butter establishments, ice making, seltzer water, also for medical and surgical uses, especially in operating halls where a large supply of sterilized water is required. The device can also be used for establishments such as hotels, schools, military quarters, and elsewhere, owing to its large output.

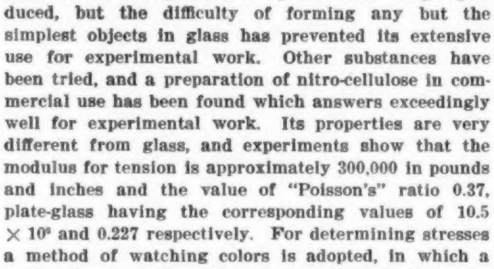
The authors made researches to find out whether the water which is sterilized by the action of the ultra-violet rays differs in any respect from ordinary water, except as to absence of microbes, as it would be a disadvantage to have the water show any taste or odor. Such is not the case, however, and no difference can be perceived. Scientists agreed that the microbes were destroyed, but some of them claimed that this was not due to the ultra-violet rays, but to the formation of ozone or hydroxyl. As to ozone, the authors made careful tests and showed that the odor of the air near a mercury vapor lamp is not due to ozone, but to the ionization of the air by the rays. Such air was passed through water, but no trace of ozone or nitrogenous products could be detected even with the most sensitive reagents. The same holds good when the lamp is immersed in water for ten minutes, so that the microbes destroying action cannot be due to ozone, nor is it on the other hand due to the formation of hydroxyl. It was only after ten hours' immersion of the lamp in water that Miroslaw Kernbaum observed the commencement of hydroxyl formation. But the authors' first sterilization experiments lasted only one minute, and in the new apparatus the microbes are destroyed instantly, so that the effect cannot be due to any chemical action. It seems quite evident that a purely physical effect enters in here.

Another advantage is that there is no heating of the water, and it preserves all its gases and salts, so that there can be no change in the taste or other qualities of the water. Only the microbes or toxines are destroyed.

This latter effect was well brought out by experiments made at the Medical College of Lyons with the apparatus which we have just described. Water containing 1 billion pathogenic microbes per liter (0.26 gallon), of which more than 100 million were coli bacillus, came out of the apparatus so completely sterilized that not even a single microbe was found in a liter of the water. Not only are the microbes killed, but the toxines produced by them are attenuated or destroyed. It is curious to observe that science here imitates the process of nature in sterilizing water, seeing that sunlight has the effect of restoring water to its original state, this being no doubt due to the same cause. However, the action is now concentrated to such an extent that the result is instantaneous.

DETERMINING STRESSES.

Before the British Association for the Advancement of Science, Prof. E. G. Coker, M.A., D.Sc., read an address in which he said that the experimental determination of the state of stress in a body by purely mechanical means and apparatus has the disadvantage that it is necessary for accuracy of measurement that a definite length, area, or volume be maintained in a standard condition, and the stress at a point cannot therefore be accurately determined if the stress is a rapidly varying one. The property possessed by glass of becoming doubly refractive under stress has been frequently utilized to determine the state of plane stress at a point in it by the color fringes produced, but the difficulty of forming any but the simplest objects in glass has prevented its extensive use for experimental work. Other substances have been tried, and a preparation of nitro-cellulose in commercial use has been found which answers exceedingly well for experimental work. Its properties are very different from glass, and experiments show that the modulus for tension is approximately 300,000 in pounds and inches and the value of "Poisson's" ratio 0.37, plate-glass having the corresponding values of 10.5 $\times 10^6$ and 0.227 respectively. For determining stresses a method of watching colors is adopted, in which a uniformly stressed test-bar is loaded until the color produced by the retardation of a plane or circularly-polarized ray corresponds to that produced at a point in the object under stress. The relative retardations R of the ordinary and extraordinary rays is assumed to be similar to glass, and to follow the law expressed by $R = C\ (X - Y)\ T$, where X, Y are the principal stresses at a point, T is the thickness of the material



Before: 1,800,000 microbes per 0.061 cubic inch. After: Absolute absence of microbes.

WATER BEFORE AND AFTER INSTANTANEOUS STERILIZATION BY NOGIER APPARATUS.

and C is an optical constant. The stresses at the cross-section of an eccentrically-loaded tie-bar and at the principal section of a hook are shown to be in fair agreement with theory. To determine the lines of principal stress in a body the loci of points at which the directions of the principal stresses are the same are found by using plane polarized light, and from the curves so found the directions of the principal stresses are determined. From the curves of principal stress, coupled with a knowledge of the position of the isochromatic lines, the stresses at any point may be determined by the use of Maxwell's method.

ELECTRO-PLATING OF METALS.

METHODS OF NICKEL-PLATING.

NICKEL-PLATING.

THERE are various methods by which metals, either heated and immersed in boiling fluids, or also at ordinary temperatures, can be plated with other metals; but, manifold as they are, and desirable in many respects, they have been almost entirely superseded, at the present time, by the special method known as the electro-chemical or galvanic, i. e., electro-plating.

It is well known that certain solutions of salts, under the influence of the electrical current, are decomposed in such a way that the metals contained in them are separated. It has become possible to effect the precipitation of the metal upon any surface which is a good conductor of the electricity, whatever its form, and upon this depends galvano-plasty and electro-deposition.

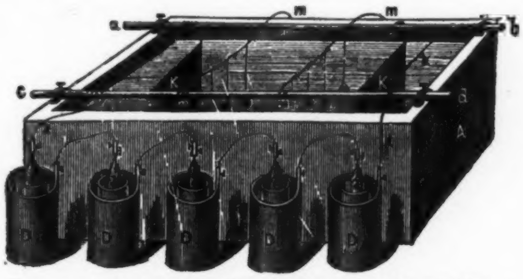


FIG. 1.—APPARATUS FOR ELECTRO-PLATING A NUMBER OF ARTICLES SIMULTANEOUSLY

In the beginning of this art, only copper solutions were decomposed by the electric current, and thus only copper articles could be electro-plated, but metal workers soon learned to separate other metals in the same way, and to deposit silver, gold, tin, nickel, etc. They have even gone so far as to be able to separate two metals at the same time from mixed solutions, and in the same proportion in which they are present in the solutions, whereby articles can be electroplated with gold and copper alloys, with silver and copper, with bronze (copper and tin), brass (copper and zinc), and so on, so that electro-deposition may be said to have been developed into a kind of cold casting.

The thickness of the metallic coating depends solely upon the length of time during which the current is allowed to work; plating several centimeters thick can just as easily be obtained as coatings whose thickness is actually immeasurable by the finest instruments.

It is easy to see why all earlier methods are falling more and more into disuse, and electro-plating, in the real sense of the word, supplanting them. In the old methods, the work was always more or less complicated and circumstantial; in the case of some of them, notably fire-gilding, there was the additional disadvantage that the process was injurious to the health of the workmen, as well as being very dependent upon individual skill; the failure in the gilding of an important piece of artistic work, for instance, may often have decidedly serious consequences.

All these objections are absent from the galvanic process; the only essential, in most cases, is a fluid of a certain composition, which can be used to plate various metals, by the simple method of connecting them with the source of the galvanic current, and immersing them in the fluid.

The thickness of the plating depends, as has been said, upon the length of time of immersion, and by varying the composition of the fluid, either bright or dull platings can be obtained, and the thickness of coating can be measured so exactly that not one milligramme more of gold or silver need be deposited than is desired.

It has long been known that certain quite common metals are especially adapted, by reason of their luster, beautiful color, hardness, and resistance to atmospherical influence, to the purpose of coatings for other metals. But the processes of obtaining these metals, such as nickel and cobalt, had so many technical difficulties, that they were for a time extremely expensive and thus not practicable for ordinary use. Galvanism has made it possible to deposit these metals from the solutions of their salts upon other metals, and thus to protect the latter excellently. We see here one of the most important steps in the progress of electrochemistry; formerly metals could be gilded, silver-plated, or copper-plated, but it was impossible to plate them with nickel or cobalt. At the present time, large machines are nickel-plated, and the time would seem to be not far distant when we shall not be limited to the use of nickel in protecting machinery from atmospheric influences, but shall be able to employ it for the same purpose on bridges, roofs, etc. Cobalt-plating also appears to have a great future, on account of the properties of this metal.

The apparatus for electro-plating is in principle exactly the same as that of galvano-plasty, by means of which metallic objects are shaped under the influence of the electric current. The essential is a continuous current of fixed strength, subject to as few variations as possible, in order that the plating may be of uniform grain and thickness. In places where there are electrical plants, it is best to make use of the current which they can furnish, with arrangements to give the required tension; where such a current is not available, a battery must be employed, composed of the proper number of constant elements.

Since the best-constructed galvanic elements or cells lose strength after a time, it seems necessary to have two batteries at disposal, so that the second can be put at work while the first is being renewed, thus avoiding interruption in the work.

The illustration (Fig. 1) shows an apparatus by means of which a number of objects can be plated simultaneously. The current supplied by the battery (*D D*) is conducted to two metallic rods (*a b* and *c d*) which lie diagonally across the tank, which is filled with the solution of a salt of the metal that is to be deposited upon the metallic objects suspended by wires in the tank (*A*). Plates of the same metal are also suspended in the fluid, and connected with the rod *a b*. In nickel-plating, for instance, the tank is filled with the solution of a nickel salt, and the plates (*K K*) are of pure nickel; in silver-plating, the solution is a silver salt, and the pates of pure silver. The objects to be plated hang free on wires (*m m*).

When the apparatus is at work, metallic particles are constantly dissolved from the plates into the fluid, in exactly the proportion in which metal from the solution is deposited on the article. The plates, of course, become gradually thinner, and must be replaced from time to time by new ones.

In cases where a large number of objects are to be silver-plated, it is of importance to know just how much silver is deposited upon each one, as the price of the ware is determined by the thickness of the plating.

This is the case when German silver articles are to be silver-plated; and articles of the same character, spoons, for instance, or forks, must be done together. To measure exactly the amount of metal deposited upon each article, the Roseleur balance, named for its inventor (Fig. 2), in the illustrations, is used. This accurate apparatus consists of a pair of beams, on one arm of which is fastened a rod, bearing a ring (*A*). The spoons, forks, etc., are suspended from this ring by wires, in such a way that they hang freely, without touching each other, in the vessel containing the silvering fluid or other plating bath. The end of the rod is connected, in the fluid, as anode, with the positive pole of the battery. On the other arm of the beam is a metallic pin (*m*), whose end dips into a little vessel filled with mercury (*n*), and which is connected with the negative pole of the battery. The scales are balanced by weights in the lower pan, and the point of the pin will then just touch the mercury in the receptacle *n*. Now a weight is put into the upper pan, equivalent to the amount of silver which is to be deposited, which will cause the pin to be deeply immersed in the mercury. If, for example, one hundred spoons of equal size are suspended in the bath, and it is desired to deposit 2 grammes of silver upon each spoon, a weight of 200 grammes is put into the upper pan. The electric current makes its way from the negative pole through the mercury, the beam of the scales, the ring (*R*), the silvering bath, the rod (*a*), and back again to the positive pole. In the proportion in which silver is deposited upon the spoons, the right arm of the beam falls, and the left rises, lifting the metallic pin more and more out of the mercury. When the amount deposited has reached a very little more than 200 grammes, the pin no longer touches the mercury, the current is broken and the deposition of silver ceases. If, for sake of experiment, the spoons are weighed before and after the plating, it will be found that each one has gained approximately 2 grammes in weight, an increase which corresponds to the amount of chemically pure silver deposited. The differences in the amount of silver in the separate spoons will not vary more than a few hundredths of a gramme at most.

We cannot take up here all the branches of electrochemistry, but must confine ourselves to that one which directly relates to the plating of metals. Coatings of certain metals, such as nickel and cobalt, can, as yet, be obtained only electro-chemically, from solutions of the salts of these metals; and we will first direct our attention to the methods employed in nickel-plating.

Nickel-Plating.—Nickel is a metal which has so strong an affinity for oxygen that it is difficult to deposit it upon another metal by simple fusing processes, and even if this should be done, the coating would not be durable. It is, besides, a very hard metal, and not easily fusible, and it is only in recent times, with the modern improvements in heating apparatus, that it has become possible to melt nickel in large quantities, and to work it into shapes. The articles made from it are still quite expensive, on account of the difficulty of the work.

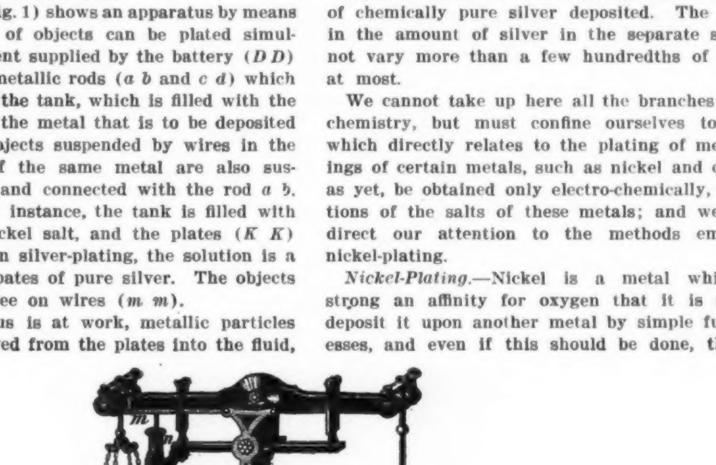


FIG. 2.—THE ROSELEUR BALANCE.

We have reason to expect that in the progress of metal-working, the time will come when we shall be able to cover copper, brass, bronze, and iron cheaply with sheet nickel, but that point has not yet been reached, and the only really practicable method now is the electro-chemical. By means of the electric

current, nickel can be deposited from solutions of its salts in any desired thickness. The coatings obtained in this way are silver white in color, very hard, and possess the property, inestimable for the use of nickel in the industries, of not tarnishing by exposure to the air. There is, then, no occasion for repolishing or cleaning nickel articles, in the real sense of the word; simple rubbing with a soft cloth will restore the luster which they may have lost through handling, etc.

In the beginning, only the wheels of watches were nickel-plated; now nickel is used on whole machines, especially in America, where nickel-plating is employed to such an extent that we cannot doubt its future as a plating for even the largest machinery.

The salts from which nickel is usually obtained are sulphate and nitrate of nickel. They can be produced by dissolving commercial nickel, which is found on the market in the form of little, porous gray cubes, in sulphuric or nitric acid and evaporating the solution, obtaining apple-green crystals of the salts. At the present time, sulphate of nickel, called nickel vitriol, can frequently be procured commercially.

Commercial nickel and also the salts obtainable in the market almost always contain small quantities of foreign metals, especially copper, which, if precipitated with the nickel, would be detrimental to the plating; and these must be removed. The nickel salts are dissolved in water, the solution slightly acidified by the addition of a few drops of sulphuric acid (the commercial nickel sulphate is usually already somewhat acid) and a stream of hydrogen sulphide gas (obtained by pouring dilute sulphuric acid over ferric sulphide in a gas generator apparatus), passed through the solution. The copper and other metals are precipitated through the agency of the hydrogen sulphide in the form of a black deposit. When the fluid begins to smell of hydrogen sulphide, the current of gas is stopped, and the fluid is carefully poured off from the precipitate, and heated to boiling in a porcelain vessel, together with a little metallic nickel, to remove the last traces of the hydrogen sulphide gas. The free acid is neutralized thereby, and the fluid, evaporated to crystallization, deposits the salt which is needed for nickel-plating, in sufficient purity for the purpose.

Nickel-Plating with Nickel Chloride and Ammonium Chloride.—Sheets and plates of pure nickel are now made in the factories, and these can be used to produce a fluid very suitable for nickel-plating. A plate of nickel is placed upon a perforated, sieve-like board in a saturated solution of sal-ammoniac, and connected with the copper pole of a strong battery. Under the influence of the electric current, the metal is gradually dissolved, and the solution of a double salt is obtained—nickel-ammonium chloride—which sinks to the bottom of the vessel, so that the metal comes again into contact with the ammonium chloride. If the nickel has been previously weighed, and the residue is weighed after a time, the amount of nickel dissolved in the fluid can be estimated accurately.

To nickel-plate with this fluid, a bright plate of nickel is immersed in it, connected with the copper pole of the battery, and the object to be nickel-plated, likewise made bright and clean, is connected, after immersion, with the zinc pole. The nickel is precipitated as a brilliant coating, whose thickness depends upon the length of time of immersion and the strength of the current.

Nickel-Plating with Nickel Sulphate.—In order to work directly with nickel sulphate, it is necessary that the salt should be entirely free from acid. To the commercial salt, from which the copper has been removed in the manner described above, a small amount of caustic soda solution is added; as soon as the free acid is neutralized, there will be an apple-green precipitate of hydrated nickel protosulphate, which is to be boiled for a while with the fluid, and filtered, after which the fluid will be found perfectly neutral. The objects to be plated are then immersed in it, and connected with the copper pole of the battery, while a nickel plate, also immersed, is connected with the zinc pole. The acid which is freed is neutralized from time to time by dropping in ammonia, or still better, by covering the bottom of the vessel with nickel protoxide, which dissolves in the acid, neutralizing the acid, and keeping the content of nickel uniform.

The nickel protoxide is prepared by precipitation from a solution of nickel sulphate, by the action of caustic soda. The precipitate, washed out and dried, appears as an apple-green powder, and can either be spread over the bottom of the plating vessel, or suspended in the bath in a linen bag.

Nickel-Plating with Nickel-Ammonium Sulphate.—If a solution of nickel sulphate, acidified by addition of sulphuric acid, is poured into a nearly saturated solution of ammonium sulphate, a crystalline pulp is deposited, which consists of a double salt—nickel sulphate and ammonium sulphate. This precipitate is washed with cold water, dissolved in hot water, thoroughly neutralized with ammonia, and left standing, at a temperature of 20 to 25 deg. C. for several days, until no more crystals are deposited; it is important to keep the fluid at the same temperature when being used for plating, as the coating of nickel would otherwise not adhere firmly.

A plate of nickel, immersed in the fluid, is connected with the copper pole of the battery; in the proportion in which nickel is deposited from the fluid, it is dissolved from the plate, and the concentration remains uniform.

Plates of pure nickel are at present rather expensive, for the reason that pure nickel requires an extremely high temperature for fusing and casting. But it has been discovered that an addition of phosphorus, one five-thousandth part of the weight of the nickel, causes it to melt at a much lower temperature. The phosphorus does not interfere with the galvanic action, and it is customary to use nickel containing it, for these plates, the best form being thin sheets. The larger the surface of the plates, the weaker may be the electric current employed. In the majority of cases, unless very large objects are to be plated, from two to four Bunsen elements or cells are sufficient.

Plating with Nickel Cyanide and Sulphate of Nickel.—Besides the methods of nickel-plating described above, others have been brought forward which give good results, but require more expensive materials, such, for example, as the double salts of nickel cyanide and potassium cyanide, and solutions of nickel nitrate.

The double compounds of cyanides of other metals with potassium cyanide are usually produced by adding to the perfectly neutral solution of a salt of the metal a solution of potassium cyanide, and stirring vigorously. There will first be a precipitation of cyanogen, which will then dissolve in the excess of the potassium cyanide solution. When but a very little of it remains undissolved, a little more potassium cyanide solution is dropped in, and the fluid stirred until the precipitate entirely disappears.

The potassium-nickel cyanate can be obtained from any soluble nickel salt—protosulphate or protonitrate—or the chloride. Silver cyanate is obtained from silver nitrate, gold cyanate from gold chloride, etc. It is a certainty that metals are very easily precipitated from their compounds with cyanogen, by the action of the galvanic current, and with very fine results; but it must also be remembered that all compounds of cyanogen are extremely poisonous, and that the fumes from fluids containing them are very injurious to health, even in small quantities; such compounds should therefore be avoided, if possible. The peculiar odor of such fluids comes from traces of hydrogen cyanide (hydrocyanic or prussic acid), the most poisonous substance known; the potassium cyanide is decomposed by the carbonic acid of the air, with generation of hydrogen cyanide.

Nickel nitrate gives a very fine and durable plating, and an effective fluid can be obtained by dissolving 4 parts of crystallized nickel nitrate in 150 parts of water, adding 4 parts of caustic ammonia and 50 of acid sodium sulphite. The latter is produced by heating copper with sulphuric acid to the boiling point, in a retort, carrying the gas which is given off (sulphurous acid) first through a little water, where the copper salt carried off with it is kept back, and then dissolving it in water, until the water smells strongly of burning sulphur. The solution of sulphurous acid in water obtained in this way is divided into two equal parts; into one part is mixed soda, until there is no longer any foaming, and to this fluid—a solution of simple sodium sulphite—is added the other half of the sulphurous acid solution, making a solution of sodium bisulphite. This must be used as it is, since the salt cannot be crystallized by evaporation; the sulphurous acid which was added would volatilize during the operation, leaving the simple sodium sulphite.

The very excellent nickel-plating as carried on in American factories is mostly done with a bath composed of nickel nitrate and acid sodium sulphite.

It sometimes happens that nickel coatings will crack off; it is said that this can be prevented by dipping the plated and dried articles in oil, and heating to 250 to 270 deg. C.

Weston's Method.—In this method the fluid is composed of 5 parts of nickel chloride, and 2 parts of boric acid, with 2 parts of nickel sulphate and 1 of boric acid subsequently mixed in, and caustic soda added, with stirring, until the precipitate is dissolved. The plating is unusually fine and durable.

In nickel-plating iron or steel, it is best to cover the metal first with a very thin layer of copper, which can be most easily done by dipping it into a weak solution of blue vitriol.

Nickel-Plating Woven Metal.—In nickel-plating lengths of woven metal, it is well to use a trough containing two wooden rollers, on one of which under the surface of the bath the sheet is rolled, with one end fastened to the other. In the center, between the two rollers, a brush of metal wire is pressed on to the sheet, serving to conduct the electricity. The sheet is plated by unrolling it slowly from one roller on to the other, and the coating can be made as thick as desired by repetition of the operation.

Nickel-Plating Containing Silver.—To give objects of iron, steel, copper, brass, etc., a coating of silver and nickel together, the article, according to A. Breden, is, after the electro-plating process, covered with a paste of zinc chloride and borax powder, and exposed to a mild red heat. The plating bath is prepared by mixing suitable quantities of silver nitrate and nickel nitrate, precipitating the mixture with a solution of potassium cyanide, and dissolving the precipitate in an excess of this compound.—Translated from the German of F. Hartmann in "Das Verzinnen, etc., und Uberziehen von Metallen."

ALCOHOL FROM SULPHITE CELLULOSE LYES.

The production of alcohol from waste sulphite cellulose lyes is discussed from an economic standpoint by W. Kiby in the Chem. Zeit. The article is of importance because the newly established industry of the manufacture of spirit from the waste lyes of sulphite wood-pulp mills is assuming great importance. Taking as a basis the average yield of 60 liters of absolute alcohol per ton of cellulose produced, Mr. Kiby shows that the prospects of the industry depend on the cost of production, the capacity of the market, and the conditions of taxation. In Sweden all the conditions are more favorable than in Germany. The total production of alcohol in Sweden for the financial years 1908-1909 was about 22 million liters (absolute), while imports amounted to 1.17 million liters. The sulphite pulp mill at Lärkudden is now producing spirit at the rate of 600,000 liters per annum, and will soon be in a position to produce 1.2 million liters, so that the whole of the imports would be equal to the product of this single mill. The pulp mills of Sweden are capable of producing about 25 million liters of absolute alcohol, and since the manufacture of spirit from the ordinary raw materials is intimately bound up with other branches of agricultural industries, it is hardly conceivable that the new sulphite spirit will be allowed to displace any considerable proportion of the present production. Further, since the sulphite spirit is of the nature of denatured spirit, owing to its impurities, it must be conceded that the future of the industry depends on the opening up of new industrial sources of consumption. The author details the probable cost of production of spirit at a mill producing 60 tons of cellulose per day. Such a mill could produce 1.3 million liters of absolute alcohol per annum at a cost of 10 pfennigs per liter, allowing 10 per cent for depreciation of capital. In Sweden the larger distilleries suffer a heavier tax the larger their production, so that, including this tax, 1.3 million liters per annum could be produced for about 17 shillings per 100 liters, and 3 million liters per annum at a cost of $9.10 per 100 liters. With the increasing consumption of industrial alcohol it is possible that even the full production of Swedish sulphite spirit could gradually be absorbed. Turning to Germany, Kiby estimates that the maximum annual production of sulphite spirit might be about 33 million liters, which would be added to the present total production. The excise regulations in Germany are particularly severe and expressly penalize new distilleries, so that in addition to the production cost of $3.00 per 100 liters, the sulphite spirit would be subject to an excise charge of $4.80 per 100 liters. German wood pulp manufacturers could therefore only produce the spirit at a loss, which they would not consent to bear unless the production of spirit would offer a solution of the problem of the ultimate disposal of the waste lyes. This, however, is hardly likely to be the case, since the spent wash would in all probability be just as obnoxious as the original waste lyes.

W. S. Rockey and H. Eldridge of New York have taken out a patent on a flux for brass plating and for protecting a bath of copper or zinc. Boric acid is melted in an iron pot lined internally with silver and is heated at a low temperature until no more steam is evolved. It is then transferred to a suitable crucible and heated at a white heat until it becomes placid, after which it is allowed to cool to a bright red heat, and a sufficient quantity of finely divided zinc, carbon, cadmium, antimony, bismuth, or other suitable element, added to decompose any remaining water of constitution, the mass being stirred until all reaction ceases. The product is suitable as a flux for brass-plating. To obtain a flux for protecting a bath of copper or zinc, silica is added to the fused boric acid just before the zinc or other element added to decompose the last traces of water, and the final product is heated to a high temperature so as to obtain a boro-zinc silicate.

THE PROBLEM OF ELEMENTAL LIFE.*

RESULTS OF NEW EXPERIMENTS.

BY T. WOOD CLARKE.

RECENT investigations on the part of certain physiologists and histologists tend to throw some new light upon perhaps the greatest of all scientific and philosophical questions, the problem of life and death. Whereas until recently the transition from the state of life to that of death was considered, at least by the medical and legal profession, to occur at the moment when the heart stopped beating, recent observations tend to show that besides this general conception of life and death, there exists also an entirely different form of life, an elemental life of the tissues, which under certain conditions may continue for long periods after the general life of the animal has ceased, after the heart has stopped beating and the personality of the individual has been lost. The elemental death begins, under normal conditions, promptly after general death has occurred and is caused by the two factors of bacterial invasion and ferment activity, the change manifesting itself by loss of cell tension and alterations in cell form, the first steps toward putrefaction and dissolution. If, however, immediately after general life has ceased to exist, fragments of tissue are removed from the body and placed in such a condition as to prevent bacterial or ferment action, the elemental life of the tissue may be maintained over long periods of time. Such a life is latent; it shows no signs of vital activity; upon such a piece of tissue being replaced in the animal body and its nutrition being maintained by a renewal of the circulation, life again becomes manifest, and the tissue renews its functional activity as a part of the living organism.

Such latent life may be of two types, potential life and unmanifested actual life. In the first condition metabolism is completely suspended as in the case of seeds kept at a very low temperature. Its application in animal life is not absolutely proved, and it is of greater theoretical than practical importance. Unmanifested actual life, however, was shown to be possible by Loevenhoeck in the case of *Milnesium tardigradum*, an animal organism which renewed its life after a long period of complete dryness. This form of latent life has been used extensively by Carrel in his work on transplantation of arteries and organs. It is the condition which normally exists immediately after general death and continues until bacterial and enzymotic action produces elemental death. Normally it lasts but a few hours at the most, but may by strict asepsis and a continued temperature between 0 deg. C. and 1 deg. C. (32 deg. F. and 33.8 deg. F.) be maintained for weeks or months. It is not a complete suppression of metabolism, but is metabolism reduced to an inappreciable minimum, to so low a grade that the changes produced are not sufficiently destructive to prevent the revitalization of the tissues.

Until recently, these two types of latent life were considered to be the only forms of life which could be maintained outside of the animal body, after general death had occurred. Stimulated, however, by the work of Harrison, who a few years ago grew nerve cells of embryo frogs in a drop of plasma, Carrel and Burrows, of the Rockefeller Institution for Medical Research, have recently carried out experiments in producing actual manifest life in adult mammalian tissue. Their brilliant results are reported in brief preliminary notes in The Journal of the American Medical Association for October 15th and 29th, 1910. The principle of the experiments was extremely simple; the technique was rendered possible by the careful organization of the department of experimental surgery at the Rockefeller Institute. The experiments consisted in removing bits of tissue from mammals immediately after killing them, the most minute precaution being taken to procure asepsis, inoculating the tissue into a drop of plasmatic medium made from the same animal, sealing it in a hanging drop slide, placing it in a thermostat at 37 deg. C. (98.6 deg. F.) and observing the changes in the tissue by means of a microscope inclosed in a warm chamber kept at the same temperature.

The results of the experiments were uniform. In every case after from one to three days, growth of the specimen was observed. After a period of quiescence, varying according to the nature of the tissue, granulations made their appearance at the margin of the tissue fragment, spindle and polygonal cells were formed and rapidly grew out into the surrounding lymph. The new tissue had many characteristics of the parent material; cartilage produced cartilage; spleen formed cells closely resembling splenic pulp; and, most striking of all, from the surface of bits of kidney grew cell tubules, replicæ of the normal kidney tubes. Once started the growth went on with wild rapidity, the cells branching out in all directions, and the process continuing for days until the nutritive power of the plasmatic medium was exhausted, and then, when once stopped by inanition, immediately becoming reactivated upon reinoculation into fresh plasma. Furthermore, fragments of the newly formed tissue removed from the parent mass and placed in fresh media continued the same active prolific growth as before its separation, the second generation of cells closely resembling the first.

The speed of growth of the tissues varied according to the nature of the material; cartilage began to grow after three days and progressed slowly; peritoneal endothelium and arterial sheath were also slow in starting and sluggish in progress; thyroid and spleen were more active, showing changes in from thirty-six to forty-eight hours; while in the case of kidney, proliferation was seen after twelve hours in the thermostat. Most interesting of all, however, was the behavior of tumor tissue. In their first article the authors report definite growth of a bit of chicken sarcoma after nine hours, and in the second publication a specimen of the same tumor had been seen actively growing two and one half hours after inoculation. Still another specimen of the same tumor, on being measured twenty-four hours after inoculation, was found to have increased in size fourteen fold, and after forty-eight hours twenty-two fold, the changes being plainly visible to the naked eye.

It is impossible at the present time to estimate the value of these observations. From the view point of the biologist the production of active manifest life—for where there is cell proliferation and growth there is manifested an active life process—is of infinite academic interest. From the philosophical standpoint a new factor is added to the great problem of life and death. To the mind of the experimental worker in medical science an entirely new field of possibility is thrown open for the study of cancer. Now that it is possible actually to see tumor cells grow and to study directly the various factors which stimulate or retard that growth, it is not extravagant to say that a gigantic stride has been taken toward the discovery of the cause of cancer and the ultimate goal of its prevention and cure.

* Science.

MORPHOLOGY.

PROF. G. C. BOURNE discussed morphology in his address on zoology, before the British Association for the Advancement of Science. The term morphology, he said, stripped of all the theoretical conceptions that had clustered around it, meant nothing more than the study of form, and it was applicable to all branches of zoology in which the relationships of animals were determined by reference to their form and structure. Morphology, therefore, extended its sway not only over the comparative anatomy of adult and recent animals, but also over palæontology, comparative embryology, systematic zoology and cytology, for all those branches of science were occupied with the study of form. And in treating of form they had all, since the acceptance of the doctrine of descent with modification, made use of the same guiding principle—namely, that likeness of form was the index to blood-relationship. It was the introduction of this principle that revolutionized the methods of morphology fifty years ago, and stimulated that vast output of morphological work which some persons, erroneously as he thought, regarded as a departure from the line of progress indicated by Darwin. What had morphology done for the advancement of zoological science since the publication of the "Origin of Species"? They need not stop to inquire what facts it had accumulated; it was sufficiently obvious that it had added enormously to our stock of concrete knowledge. They had rather to ask what great general principles had it established on so secure a basis that they met with universal acceptance at the hands of competent zoologists? It had doubtless been the object of morphology during the past half-century to illustrate and confirm the Darwinian theory. How far had it been successful? To answer this question they had to be sure of what they meant when they spoke of the Darwinian theory. He thought that they meant at least two things: "(1) That the assemblage of animal forms as we now see them, with all their diversities of form, habit, and structure, is directly descended from a precedent and somewhat different assemblage, and these in turn from a precedent and more different assemblage, and so on down to remote periods of geological time. Further, that throughout all these periods inheritance combined with changeability of structure have been the factors operative in producing the differences between the successive assemblages. (2) That the modifications of forms which this theory of evolution implies have been rejected or preserved and accumulated by the action of natural selection." As regarded the first of these propositions, he thought there could be no doubt that morphology had done great service in establishing our belief on a secure basis. The transmutation of animal forms in past time could not be proved directly; it could only be shown that, as a theory, it had a much higher degree of probability than any other that could be brought forward, and in order to establish the highest possible degree of probability it was necessary to demonstrate that all anatomical, embryological, and palæontological facts were consistent with it. Our belief in the transmutation of animal organization in past time was founded very largely upon our minute and intimate knowledge of the manifold relations of structural form that obtain among adult animals; on our precise knowledge of the steps by which these adult relations are established during the development of different kinds of animals; on our constantly increasing knowledge of the succession of animal forms in past time; and, generally, on the conviction that all the diverse forms of tissues, organs, and entire animals are but the expression of an infinite number of variations of a single theme, that theme being cell-division, multiplication, and differentiation. This conviction grew but slowly in men's minds. It was opposed to the cherished beliefs of centuries, and morphology rendered a necessary service when it spent all those years which had been described as "years in the wilderness" in accumulating such a mass of circumstantial evidence in favor of an evolutionary explanation of the order of animate nature as to place the doctrine of descent with modification on a secure foundation of fact. He did not believe that this foundation could have been so securely laid in any other way, and he held that zoologists were actuated by a sound instinct in working so largely on morphological lines for forty years after Darwin wrote. For there was a large mass of fact and theory to be remodeled and brought into harmony with the new ideas, and a still larger vein of undiscovered fact to explore. The matter was difficult, and the pace could not be forced. Morphology, therefore, deserved the credit of having done well in the past. As to the future, morphologists had to inquire into the causes which produced alteration of form, and there was a large field to explore.

At a recent meeting of the Academy of Inscriptions and Belles Lettres, held at Paris, a warm tribute was paid to the generosity of the Duc de Loubat, who had greatly aided the work of the academy by his interest and financial assistance. The Duc de Loubat has done much to encourage archæological research. For many years the excavations at Delos have been carried on and the results published through him. What is more, he placed at the disposal of the academy an annuity of 3,000 francs to aid scientists momentarily halted in their work either through lack of resources or through illness. This year the Duc de Loubat has given the academy the net sum of 3,000 francs, which enables the academy to proceed immediately with the work in hand.

During the last two years manufacturers have produced forty-five new explosives which have been officially pronounced comparatively safe and therefore permissible for use in blasting coal in gaseous or dusty mines. Prior to 1909 little information was available to coal operators or State mine inspectors relative to the liability of explosives to ignite coal dust or coal gas, and thereby to cause explosions, except the information or supposed information contained in the claims made by manufacturers of a few so-called safety powders. Early in 1909, under authority of an act of Congress making an appropriation for investigations of mine accidents, the United States Geological Survey undertook to test the explosives on the market.

INSECTS DESTRUCTIVE TO BOOKS.*

PESTS OF THE LIBRARY.

BY WILLIAM R. REINICK.

For a number of years I have been investigating the subject, "insects that destroy books," and this paper is simply a summary of a few of the facts that I have discovered and collected. No attempt has been made to make it complete, either as to species of insects, or subject matter under any particular group. These, in a complete form, with the results of the further experiments now being made to prove the theory advanced, will be published later.

Various insects have been named as the true bookworm. The insect known as the cigarette beetle, *Sitodrepa panicea*, is given as the true bookworm of Prof. L. O. Howard, United States Entomologist; but if the name of "bookworm" is given to the insect which causes the greatest destruction, then this species will have to be placed quite a distance down in the list. Personally, I will not try at the present time to settle the question as to the species which is to be given this doubtful rank.

That a knowledge of the fact that books are destroyed by insects is not of recent acquisition may be gathered from the writings of the ancients.

The earliest reference according to Austen† "was rescued from oblivion by the lad Salmasius, in 1606, when he discovered the manuscripts of the anthology of Caphalus, in the libraries of the Counts Palatine, at Heidelberg." Among the fragments in this collection is one attributed to Evenus, the sophist-poet of Paros, who wrote about 450 B. C.

Aristotle speaks of a "little scorpion-like creature found in books," which was evidently a species of *Acarina* or pseudo-scorpions. Horace and Ovid also speak of the bookworm. Pliny, in his "Natural History," has very little to say upon the subject. Martial, who lived in the first, and Lucian, in the second century, A. D., speak of the bookworm, and many other writers mention them; but it was not until 1665, when Hook, in his "Micrographia," published an account and gave an illustration of the insect, that entomologists were enabled to determine with any accuracy the insect that was named as the cause of the destruction of books. It is impossible from Hook's description to tell what species was meant; but the illustration accompanying the description shows that it must have been a species of *Thysanura* or *Collembola*, commonly known as silver-fish and spring-tails.

It has been stated that more books and papers are destroyed by small forms of life in one year than by fire and water combined; and, from the facts given by various writers, and the statements made to me in letters by many librarians and others, especially where the libraries are located in the warmer regions, I am positive that this statement is true. Those in charge of collections in the temperate regions, whose volumes are not as rapidly destroyed, are apt to doubt the enormous destruction of books each year by practically unseen life.

Again that this destruction is great enough to cause alarm is indicated by the number of prizes offered by various bodies for means to prevent this never ceasing destruction. Prizes were offered by the Royal Society of Göttingen in 1774, the International Library of Congress in 1903, etc., but as yet no satisfactory results have been obtained. I hope before long to be able to present to the world the cause of these ravages and a means of prevention.

Those who have read articles upon the destruction of books and papers by insects must have noticed that in almost all the papers the author has simply stated that the insects were after the paste used in the binding; and most of the prizes that have been offered from time to time have the same object in view. If the paste is the object of attack, why is it that photographs are not eaten which are fastened to the cardboard by means of this substance?

Although some of these writers have stated that the bindings were bored or gnawed through a gallery leading from an opening made on the outside toward the interior of the book; that the glazed surface of the paper was eaten off; that in a few cases that portion of the page which had received the impress of the printer's ink only had been eaten, making the page look as though the letters had been cut out with a punch; and again, that a cavity has been found in the interior of the book, without showing by what means the insect was able to obtain access; not one of them, as far as I can find, has reasoned upon the question that there might be other causes for these ravages of the insects upon books besides the hackneyed phrase that "they are after the paste used in the binding in order to obtain the starch contained in it."

Having read hundreds of articles and notes upon this subject, and having had the pleasure, from my standpoint—but not that of the librarian—of examining many hundreds of volumes of ancient and recent date of publication, with bindings made of different leathers, paper made of rag, wood, and other materials, my attention was before long attracted by the fact that in the great majority of books examined no attempt was made by the insects to eat the paste used in the binding, and also by the many cases in which a cavity or cavities were found in the interior of the volume without showing the means by which the insects obtained access thereto.

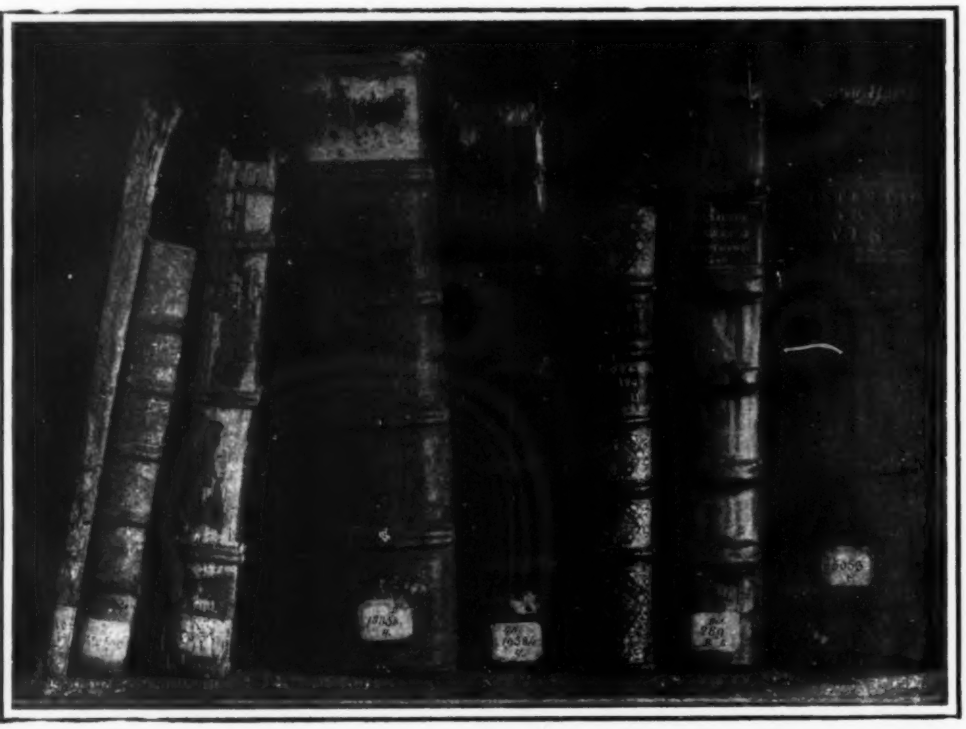
Looking at the various ways in which books were ravaged, and knowing from my own studies and observations in entomology that the insects have wonderful instinctive powers, which in a number of cases could very easily be classed as intelligence, I have come to the conclusion that there must be other reasons besides the desire for paste to cause these various depredations, and I have asked myself this question: As we know that the dog and cat, when sick, look for certain herbs, grasses, and putrid animal matter, being directed by their instinct to that substance which contains the vegetable and the mineral matter which are best suited for the particular ailment from which they were suffering at that particular time, may not the insect, with an instinct as great, if not greater, have use for them for the same purpose? It seems to me that the lower we go in the scale of life, according to the classification of the systematists, the more wonderful are the instinctive faculties of the small forms of life, and that if a classification were made according to instinctive faculties, it is a question whether the ants would not outrank the animals by many degrees.

The new school of medicine, in departing from the system of the old, that in which Hahnemann in following Paracelsus claimed that certain symptoms in human beings required mineral agencies and vegetable compounds in potencies equivalent to the complaint, neglected to study the power of drugs, and results not anticipated frequently occur, caused by not using judgment in the quantity of the dose given. Those interested in finding means for destroying life that is destructive should use such means in their researches as those advocated by Hahnemann.

Starting upon this theory, which I contend will be found to be true when biologists, physicists and entomologists have searched more deeply into the evolution of the lower form of life, I divided the books into classes according to that portion which was damaged, and will describe some of the most important and name a few of the insects which attack that particular group.

Paste Eaters.—Science has proved beyond doubt or question that there can be no destruction of matter, only a change of form. If there is no destruction of matter, then we have a demonstration of the theory of the worm or larva having been attracted to the paste used in the binding of the books. In the agricultural kingdom we find that rye, wheat and the various other varieties of grain are constantly being

WOODEN BINDING OF SIXTEENTH CENTURY RIDDLED BY LARVÆ OF BORERS (ANOBRIUM)

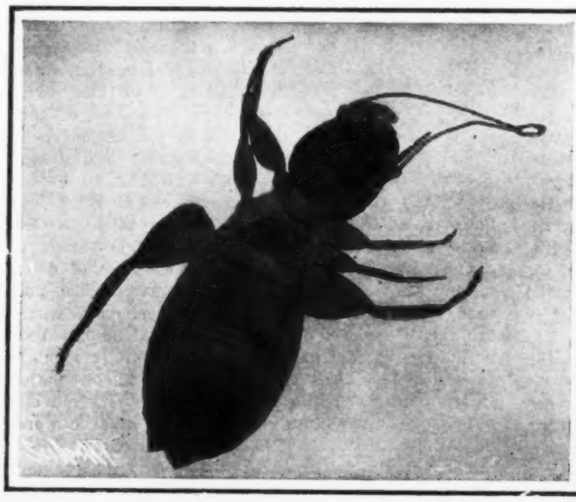


BOOKS INJURED BY BOOK LICE, "SILVER FISH," ETC.

THE INSECT ENEMIES OF BOOKS.

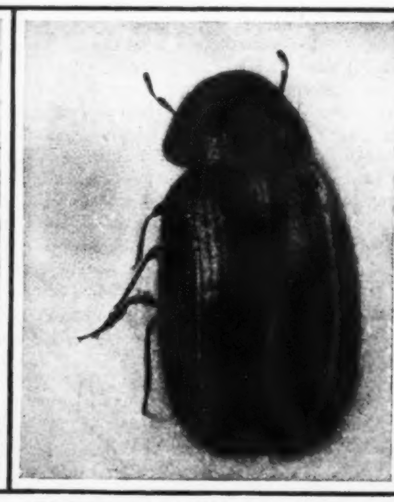
† Bookworms in Fact and Fancy; Popular Science Monthly, 1899, vol. lv.

damaged by the work of different species of insects. These insects and other small life live upon the exudations of plant life, and the human body is also giving off exudations in the form of perspiration which is also a source of nourishment to many forms of life.



PSOQUE OR BOOK LOUSE.

(Magnified about 60 times.)



BREAD BORER (ANOBRIUM PANICEUM).

(Magnified about 4 times.)

SILVER FISH (LEPISMA SACCHARINA).

(Magnified about 3 times.)

CHYLETUS ERUDITUS, A USEFUL "BOOK WORM."

(Magnified about 10 times.)

A RECENT BOOK (1834) INJURED BY DESTRUCTIVE INSECTS.

FLY LEAF AND TITLE PAGE OF A VALERIUS MAXIMUS IN THE LIBRARY OF THE ARSENAL, PARIS, RUINED BY INSECTS.

THE INSECT ENEMIES OF BOOKS.

We will take rye and wheat, which are principally used in paste making, as an example. The whole grain is taken to the mill, husked and ground, and prepared by various processes for the sustenance of the human family. After all the processes of the miller have been completed, it is barreled or bagged and is ready for distribution. In the processes we find that alum has been and is still being used as a whitening agency for the different grains. The flour is taken into the factory apparently pure, clean, and free from all forms of animated life; but in a very short time, especially if it is kept in a compartment that is heated, or in a moist atmosphere, and is left standing some time before being used, life is apparently created in it, a puzzle to all, as to its origin and nature, and stranger still, the first life noticed is worm life always. In this case it is known as the "flour worm." Mr. James Stone, a flour merchant of Philadelphia, in reply to my questions, stated that they always discovered the worms first, that they were only found in the center of the barrel, never near the sides, and that the loose flour lying around the floor, of which there was always a quantity, was never found to have worms in it. The lower or coarser grades which are used exclusively for paste were first damaged. The finer grades were seldom found to be affected. This goes to prove my theory that the life was in the flour before grinding, and that it lay dormant until the proper conditions were produced, such as heat and dampness. The grinding of these grains allows the gases in the air to reach the particles, which to a large extent, were before protected by skin or husk. These gases cause a chemical change to take place, which has been little studied, and this will be found to give food for worms which were heretofore in a dormant condition. Many eggs of the smaller forms can hardly be seen, even with a compound microscope. The following are some of the species that may be classed as paste eaters: *Pyralis farinalis*, a moth, and *Tenebroides mauritanicus*, *Silvanus surinamensis*, *Calandra granaria*, and *Tenebrio molitor*, all beetles.

PAPER.—Paper is made from cotton, linen, hemp, rags, and waste, from chemically prepared woods, from straws, from bark without the wood, from wood not chemically prepared, and many other substances. In a great many papers, clay and other materials are added as fillers. While we are conversant with the various processes used by paper manufacturers, yet very little attention has been given to the real character of life that dwells within the manufactured product in its primoid state. Cotton fly is used for low paper stock, and the little insect that infests the cotton boll, known as the cotton weevil, sends forth its offspring under a different form, yet with all the instincts of itself.

After the paper has passed through certain stages, but not with sufficient intensified heat to destroy the principle of existence, the species evolutionizes into another state or mode of living. In the broader conception of biological truths, ready answers are given to this profound question, i. e., the origin of various forms of life, and the searcher has ready for the querist the proper foundation whereon to build the superstructure of that truth, which the arcanum of nature reveals to the desires of the mind of the scientist and physicist. Too little attention has been given to the manuscript notes of scientific workers, often only a line or two of their observations upon the small forms of life. The average scientist thinking it too trivial to notice, often passes over the very observation which is the key to the puzzle that he has been spending years in trying to solve.

PAPER EATERS: WOOD PULP.—A species of insect, frequently found in libraries, is the *Cimex lectularius*, vulgarly known as the "chinch" or "bed-bug." Its natural instinct leads it to wood on account of certain poisons in the form of acids contained therein, and certain nourishments which are of a poisonous character to the human being, but beneficial and necessary to insects and worm life. Where paper has been manufactured from wood pulp, containing the particular acid or poisons which the "bed-bug" requires, there you will find the insect with all its instinctive faculties. Why do they live and thrive under wall paper? Many wall papers, some of which are known to be a cause of illness to mankind, have large quantities of arsenic, cochineal and Paris green in them. This mineral compound being changed by the continual variation of the temperature going on in the room, is sufficient to alter the natural character of the paper, and also the habits of the bugs, who are thus able to obtain nourishment from the back of the paper.

Among this group are to be found the following beetles: *Apate capucina*, *Xestobium tessellatum*, and *Lyctus unipunctatus*.

PAPER EATERS: VEGETABLE FIBERS.—In the Aztecan history many of the primitive documents were made from banana skin. These were made to receive the imprint just the same as paper is manufactured for printing to-day. A sample of this paper was placed in a perfectly sealed case, and a scholar wishing to refer to it one day, upon going to the case containing the writing, was astonished to find that all the paper had been destroyed, although the case was still impervious to any attack made from the outside. This demonstrates how long life may be prolonged in insects being placed away from their natural surroundings, continuing the life cycle whenever the proper conditions are given.

Trichophaga tapetzella, *Tinea pellionella*, *Tineola biselliella*, and *Plodia interpunctella* are a few of the moths that bore into paper in order to obtain access to the fibers.

PAPER EATERS: MINERAL FILLERS.—This group includes papers where quantities of clay and other mineral substances have been used as fillers. For an illustration we will take the character and life habits of the *Termites*, or white ants, which are in a measure destructful to material utilized in the manufacture of paper. The alluvial deposits are natural to the white ant, consequently, when clay is used in the manufacture of paper, the instinct in the ant leads it to feed upon that which is natural to it, especially if the books have been kept in a place

where it is damp. The lower organic life is, but in a measure, an evolution that is manifested in the higher and more complex forms of life. In the mountainous regions of North Carolina is found a collection of people who eat large quantities of clay which is found there in abundance. These creatures, the whites being designated as "poor white trash," and the negroes as "blue-gummed negroes," are addicted to the habit of clay eating, and nearly all are veritable living skeletons. The eyes and gums of the whites have a reddish hue, and their skins become a dirty yellow. The gums and skins of the negroes take on a bluish hue. This clay contains arsenic, and, instead of clay-eaters, they might more properly be called arsenic eaters. The supply of clay for daily use is provided with more energy and precision than food. This clay poisons the saliva exuding from the glands of the mouth, and also from the base of the teeth, and makes their bite probably poisonous.

And so we see the special laws of nature, by which forms of low life live, actuated by the first principles of their instinct to return to their primitive mode of feeding; that is, the life that is generated from the botanical kingdom, much in sympathy with the facts established by Dr. Hahnemann, which verifies the principle that like attracts like.

Monorium pharonis, or red ants, *Termites*, or white ants, are found destroying paper that has clay in its composition. The first named is also fond of saccharine that is found in wood fiber.

PAPER EATERS: ANIMAL FIBERS, PARCHMENT.—Insects, such as roaches, which destroy parchment, are after the oils and fats which are used in their preparation; for, however carefully the parchment may be prepared, there is always a certain amount of oil and grease left in it. These oils are obtained from the plants, minerals, and animals of the earth which the roaches have always been used to; therefore, when placed in a location away from their natural food supply, their instinct compels them to seek those books which have the foods, etc., in their composition to which roaches formerly had access. After the processes of the manufacture of paper have been completed and it is ready for the printer, another transitional change is nigh, due to the chemicalization of the inks that are used.

Parchment is especially eaten by the roaches, *Periplaneta americana* and *Ectobia germanica*, the crickets, *Gryllus assimilis*, and some species of *Coleoptera* or beetles.

SKIN BINDINGS.—Bindings made of skin always have a certain amount of oily or gelatinous substances in them, even though they may seem perfectly dry to the observer, and these bindings are subject to the ravages of the insects, that in their natural state go after substances containing oils and greases. Leather that is perfect in its external appearance, under degrees of dampness will expand, and under degrees of heat will contract. The oil is hidden at the bottom, and does not come to the surface until pressed out by expansion caused by dampness. The skin contains the same elements in the dead state as in the living, and the bindings will be attacked by the same forms of life that lived upon the live animals, because they can still find the mineral poisons and the alluvial substances that were part of their natural food supply. Leather bindings are also subject to the depredations of insects and worms which are partly after the oils, acids, and fats that are in the skin, as well as from the new life that has been conveyed to it by the uncleanliness in preparing the leather, not including the hundreds of substances, many of them poisons, especially tannic acid used by the tanners for tanning purposes, which are also attractive to other species of insects. And just as the animals which eat the plants containing various chemical elements thus become impregnated with acids, so will the insects living upon animals and plants be found to have acids in their compositions.

The leather is destroyed by a number of species of beetles, such as *Lasioderma serricorne*, *Attagenus picous*, *Dermestes lardarius*, and *Anthrenus scrophulariæ*.

WOOD BINDINGS.—The beetles, *Anobium hirtum* and *Ptilinus serricornis*, are found making galleries in the wooden covers of books.

POISONS USED, MINERAL.—We have in the minerals of the earth many poisons, one of which, arsenic, is of special interest, as it has been the established rule of the wall paper manufacturers to use it in large quantities; and this poison is one that attracts various species of insects on account of its medicinal value. Just as human beings take poison in proportionate ratio to the needs of their systems, and especially arsenic for their health, so do the insects and lower forms of life, which have an instinct beyond the ordinary comprehension, need it; and they find it in the wall papers and colored illustrations printed on the bindings and in the books. Where sulphur is used, other species will be attracted, and so on with the various poisons which are used in the arts. The "bed-bug" also finds food in the poisons used, such as arsenic, Paris green, etc. The idea that this insect is only found where uncleanliness prevails, has long since been rejected, as it is constantly found where absolute cleanliness rules.

Flies will cling to wall paper, especially in damp weather. This is due to the moisture in the atmosphere causing the poisons in the paper, which flies are primarily after, to become soft enough for them to eat.

GASES: FROM HEAT.—It is accepted as a fact by scientists to-day that the nature and character of life, in the material sense of evolution, has for its base the heat generated by the physical sun, assisted by the moisture of the atmosphere, and the darkened chambers of the earth, which are necessary in the first stages of all life production. Books in a very dry and warm location will be found to be subject to attacks of *Thysanura* and *Collembola* which are naturally attracted by heat; and, as heat rises, the books on the top shelves will be found to be the ones damaged by insects. They are seldom found where it is damp.

The spring-tails, *Lepidocyrtus americanus*, and the silver-fish, *Lepsima saccharina*, come under this group.

GASES, POISONOUS, ETC., COMBINED.—The tree from which is made the wood pulp used in the manufacture of paper, has its roots shooting down into the bowels of the earth, and its branches and leaves reaching up into the heavens. The roots are fed by a varied combination of elements, mineral, gaseous, and vegetable, and these elements, taken in by the roots, are by a wonderful system of arteries carried into every portion of the tree, and insects are thus able to get all the elements that are necessary for them to sustain life. The pores of the skin are the health-holes of the body, and in a sore, unless it is sterilized, life is bound to start, and that first life again is worm life, no matter how carefully the wound is protected on the outside. If a microscope were used, the body would be found to be covered with animated matter. The insects, preying upon animal life, are after the poisons exuded by the skin and blood.

OMNIVOROUS.—Among the insects which can find food in all portions of the books may be mentioned the beetles, *Sitodrepa panicea* and *Tribolium confusum*.

CARNIVOROUS.—The following are some of the forms of life found preying upon insects found in libraries: the centipede, *Scutigera forceps*, pseudo-scorpions, *Bryobia praetensis* and *Tryoglyphus longior*. I believe that investigation will show that the last two species are injurious to books.

RESEARCHES.—Some of the statements here made may seem radical, but when it is considered how little is known of the habits of the lower forms of life, on the one hand, and the facts given by the few life histories that are known, on the other, it does not appear to me unreasonable to place this theory before the public. Especially so, as my own experiments are showing results entirely different from anything hitherto published.

It is known that the eggs of the insects under adverse conditions will stay fertile for long periods of time; that the eggs will also stand a very high or low temperature; and, on account of the toughness of their skin or shell, are also able to stand a great deal of handling and pressure without being crushed or broken. At an institution with which I was officially connected for a number of years, a lot of mosquito eggs were received from Cuba. These eggs had been attached to a piece of rough blotting paper, and sent to us through the mails. Upon receiving them, thinking that they had been ruined by rough handling and pressure that they must have received in transit, the blotting paper was thrown aside and allowed to lie exposed to the dust of the atmosphere and the rays of the sun for many months. One day, in a spirit of fun, someone threw the blotting paper into some water, and, to the surprise of all, in a very short time the larvæ were swimming around as though nothing had ever happened to them.

All plants, vegetables, trees, etc., have certain combinations of chemical elements which are only found in them, as is known from chemical analyses, which have been made of material from them, and whenever any of these trees, etc., are used in the manufacture of paper and the preparation of leathers, eggs of the different species are most likely to be found incorporated in the material. Hibernating, as it were, until the proper conditions through heat or dampness come about, giving vitality to the germ within, and in a very short time the little worm is enjoying life, although being evoluted, perhaps, later than nature intended it to be.

Again, wandering insects come into the library, and their instinct tells them what books contain the particular food or medicine which they are seeking. These little insects pass through various states of evolution, with long periods of life, which are known to the finite mind as to the exactness of the length of their lives, and are always evoluting up to a point of superior consciousness. We must give credit to the entomologists for their researches as to the laying of the eggs of the winged insects, that in time by the active energies of the physical universe, produce life which becomes expressive, by a process of incubation which has been very little considered. These various illustrations are exhibited to express the nature and character of that which has been infectious to the libraries of the world. While many of them will seek for the paste, it is not always that which attracts them. They are also attracted by the mineral and vegetable substances found in books.

DISEASE CARRIERS.—Just as diseases are carried by flies, the seeds of plants by birds and the winds, so are contagious diseases carried to new locations by books and papers. Flies coming from putrid matter, or from a person suffering from a contagious disease, by depositing disease germs on books, provide the means, if given the proper conditions, of spreading these diseases to a locality where they were unknown before, not to mention the possibilities of fleas, germs and bacteria. From my knowledge of the ability of bacteria to attach themselves to paper, I am positive that future research will show that books and papers have been the means of spreading many cases of disease. The question of doing away with bank notes has been agitated for years, on account of the disease germs and bacteria carried on them, absorbed from the unclean hands which handle them. A letter received by me from the United States Bureau of Animal Industry states that "several years ago, however, at the request of a Representative in Congress, an examination was made by this bureau of a one-dollar Treasury note with the view of determining the number of organisms thereon." The note used for the investigation was obtained on February 3rd, 1904, from the U. S. Treasury, having been withdrawn on that date from circulation. It belonged to series 1890, and hence had been in circulation thirteen years. While the note looked very old and quite soiled, one often received notes of even worse appearance in ordinary business transactions.

The note in question was subjected to the ordinary laboratory manipulations for determining the number of micro-organisms upon it which were capable of vegetation and development, and as a result of this examination it was found that there were 13,518,000 living micro-organisms present on this note. These consisted principally of the organisms popularly known as bacteria and fungi. Uncleanliness is more to blame than the paste in the books for the insects found destroying them.

The fleas, *Pulex serraticeps* and other species, and the *Acarina* or pseudo-scorpions, are also capable of carrying disease germs.

REMEDIES.—As far as the destruction of these insects by poison is concerned, they are practically worthless, because whenever the poison is used to destroy one insect it will attract other insects who have need for that poison. Uncleanliness of the human family also helps to supply the needs of a book-worm. Men and women who do not give the proper consideration to their hands, going from the dining room into the library, either public or private. Nature, by its process under the great infinite power, has supplied the skin of the human body with scales and pores, and these, acting upon their functional duties, are constantly discarding that which the body in a healthful state does not want. In perspiration, which is moisture, there is thrown out from the pores of the skin a combination of mineral and vegetable acids, which may all be summed up in one word, "dirt." This combination or dirt contains food for a number of species of insects. When hands, which are soiled, are laid on clean paper, some of the matter attached to the hands will be left upon the paper, in this way producing food for insects. We say this because man from a material standpoint has his grosser body made of matter, and matter in a concrete form is the dust of the earth. Cleanliness in the handling of papers, books, and documents will be of more value than all the poisons combined. Let common sense prevail, make sanitary rules in the home and in the public library an enforced rule, and it will lessen and arrest the rapid growth of the little insects which feed upon our silent friends of so much value to us, besides eliminating the possibilities of contagious diseases. The library of the future will be found to contain lavatories where every one wishing to make use of the books in the collection will first have to thoroughly cleanse his or her hands. This is a subject which should be considered in the near future by the bacteriologist, as well as the entomologist, biologist and general visitors to the halls of learning.

At a general meeting of the Aeronautical Society, resolutions were passed eulogizing the career of the late Octave Chanute. He was referred to in the resolutions as "practically the founder of the science of aviation, who was many years in advance of others."

THE MODERN VIEWS OF HEREDITY.*

GALTON'S AND MENDEL'S PRINCIPLES AND THEIR APPLICATION.

BY CHARLES L. DANA, M.D., LL.D.

Heredity, as I understand it, means that mode of biological activity by reason of which one generation transmits its characteristics to another. It is one of the phases of that special activity of protoplasm, which used to be called "vital force." It is a kind of memory in the cells. By it parents transmit to the offspring similar organs and functions, so that one species reproduces its kind, and also the traits of the family and individual. Heredity represents and carries along in its activity something of all the previous ancestors. Man has what Galton calls a "nature" or individual character and personality. This is made up of three things: (1) Most important, is his heredity or his inherited character. (2) Certain changes or additions, due to accidents of his conception and growth before birth. (3) The acquired traits which result from his education and environment. We cannot express in figures how large a part of man's "nature" belongs to heredity. It is the large and fundamental part, especially as regards general characters and species. It has been generally believed, and is still maintained, that the *mind* of man has a "nature" in which individual action is freer, and that our mental inheritance can, in good measure, be controlled and directed by what is added or acquired. So that, as man evolves and becomes more developed as regards his brain and intellect, he becomes less a slave of his inheritance, and the freedom of our will is, in a sense, measured by the development of this intelligence. The influence of heredity, then, would lessen in the higher types of civilized man. This view, however, which is so hopeful to the moralist and educator, is absolutely denied by Pearson, who asserts that the mental and moral qualities are just as much a matter of stock and ancestry as are the physical qualities.

The subject of heredity is studied by the cytologist from a purely morphological and physiological point of view. This phase of biological science is one which is quite apart from that with which I am concerned now.

For there is another class of investigators who study simply the general facts of heredity, using statistical methods upon large groups of individuals, making measurements, determining which are laid down in the technical language of the mathematician. These investigators are working along two lines: One group call themselves *biometrists* or *biometricians*. They are the followers of Galton, and their work is published in a large, technical journal, and in various special pamphlets.

Still another group of investigators is following the principles discovered by Mendel, and are known as *Mendelians*. I do not mean to say that they are mutually exclusive in their lines of work, for they are not, though there has been a certain antagonism between the methods of the biometrist and of the Mendelian. There seems, however, to be now a coming together of the two.

Now, out of the enormous mass of statistics and observations which have been accumulated regarding heredity, so far, there have been only two principles evolved which can be considered laws. The first of these is "Galton's law of ancestral inheritance," modified by Pearson, and the second is "Mendel's law." Galton's law is simply this: that of all the heritage which an individual possesses, one-half, on the average, comes from his parents, one-quarter from his grandparents, an eighth from the great grand-parents, and so on. Supposing, for example, that there are two parents, both of whom have a distinctive mental or physical trait. The child, it is found, has somewhat less than half of these traits. How would this be explained? Under the law of Galton, it occurs in this way: the 50 per cent of traits which he might have inherited from his parents, is offset in a measure, by the absence of these traits in a large part of the ancestry which preceded. On the other hand, if the child had more than the talent of the two parents, it is not that their union intensifies this talent, but that there were also evidences of the same talent in the grandparents and other antecedents. This law explains, in a degree, the inferiority of the children of parents who have been distinguished in certain lines, a fact so often observed.

As may be seen, this law of ancestral inheritance helps us in predicting, in a very general way, the nature of prospective generations. It tells us, for example, that a family in which large numbers of certain characteristics exist, will be apt to continue to breed these characteristics. It explains the puzzling fact that the children of geniuses all seem to be rather inferior; and yet, that genius is hereditary. It is hereditary not because the parents have it, but because it is in the ancestral lines, and spreads largely throughout the family tree.

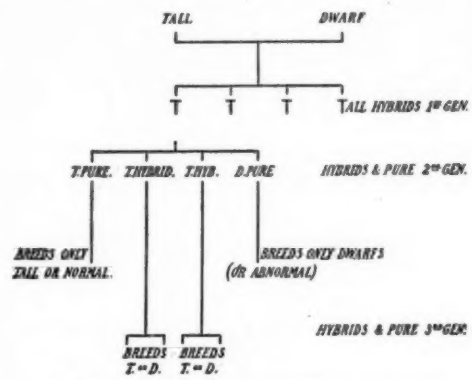
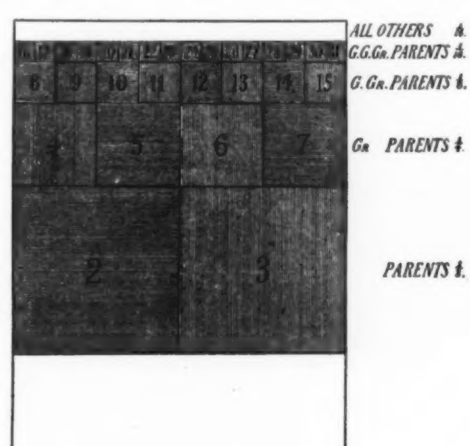


ILLUSTRATION OF MENDEL'S LAW.

Mendel's law is not a thing that can be stated in any simple formula. It is based, in the first place, on the fact that characters in an individual are transmitted in a unit form, and are not blended with an opposite characteristic, and, secondly, that these unit characters tend to combine in definite proportions, so that, for example, if a tall man and a short woman marry, the characters of tallness and shortness would show in the offspring in a certain definite proportion. Mendel was enabled, for instance, in breeding tall peas with dwarf peas, to predict that at the end of the fourth generation, there would be so many talls and so many shorts, in the proportion of about 1 to 3.

The law, therefore, concerns itself with the phenomena of hybrids, of the breeding together of individuals that have distinctly opposite or pairs of characters, so to speak. When a pure type of one kind like a tall pea breeds with a pure type of another, for example, like a dwarf pea, it forms a hybrid. Now, when *these hybrids* are bred together, their offspring will not all resemble their parents, but will differ in a certain mathematical ratio. About one-fourth will be like one original pure or tall parent, another fourth will be like the other original pure or short parent,



GALTON'S LAW OF ANCESTRAL INHERITANCE.

and one-half or 50 per cent will be crossed forms. So that the offspring of the breeding will be represented by the formula:

$$B^2 + 2\,BR + R^2.$$

Of these, the pure individuals, *B* and *R*, will breed true indefinitely among themselves, as to the character in question, while the crosses bred among themselves will again split up into pure and crossed forms, in the same proportion of 1, 2, 1. In other words, the offspring in hybrids will not be hybrids, but half pure and half hybrids.

A second factor of Mendel's law is a distinction between what he calls *dominant* and *recessive* characters. This means practically, that the 50 per cent of hybrids may appear to be like one of the pure forms because, of the two characters of which they are made up, one is dominant to the other, and conceals it. This is shown in the diagram where it is seen that when tall peas are bred with dwarf peas, all the products will be tall because the tall character is dominant, while the dwarf character is recessive.

All this, no doubt, seems very difficult to follow, but, in a way, the dominance and recessive character of special traits are shown all the time in human heredity. We mix the black race with the white, and the black is always dominant. In the marriage of a man who has a mild neurotic taint, with a perfectly healthy woman, the offspring may be healthy because, although it contains still the neurotic taint, such, for example, as the migraine, yet it is recessive to the normal character of the family. On the other hand, a man who has had a distinct development of a serious psychosis, like a recurrent melancholia, marrying a normal woman, would have children in which the dominant trait of melancholia would appear in some of the offspring. The law of Mendel cannot apply strictly to the human race, in most instances, because it is a law which has to deal with individual characters, and human beings are made up of so many characters that the problem becomes too complex, and one character is submerged by the dominance of others. Still, in certain peculiar abnormalities, such as color-blindness, peculiar dystrophies, and other hereditary or family diseases, the Mendelian law has been shown to apply with a fair degree of accuracy. Furthermore, the general principle that hybrids do not breed true, but breed mixtures, pure and recessives, can be applied probably with safety to the intermixtures of families and, perhaps, of races.

Some further remarks may be made regarding the methods of the study of heredity, and the principles which are being utilized. The followers of Galton, the biometricians, base their work upon statistical methods, and deal with large groups of individuals. They have evolved a number of special laws or methods by which certain relationships can be formulated. There is, for example, what is known as "Yule's law" or "formula." This is a formula by which one can determine the relationship between certain conditions, as for instance, the relationship of deafness to albinoism.

There is also the factor of regression, which is one of the principles connected with the law of ancestral inheritance. In other words, it is the tendency for persons deviating from the average, to return to the same. This is the tendency already referred to which underlies the well-known fact that exceptional men have children who are, as a rule, not so exceptional. The sons of tall parents are a little shorter than their parents, and the sons of short parents are a little taller. It is the ancestral pull, so to speak, the force of the whole inheritance which tends to bring the individual back to the mean. Following out this principle, it has been shown that the extremes of a race, that is, those representing some specially valuable or bad quality, are less productive than the means.

Thus, there are influences at work all the time to diminish the bad effects of heredity on the race, at least, although at the expense of the family. But these influences do not work perfectly if the lives of the parents and the functions of the parents are not regulated in accordance with the rules of ordinary healthful living.

There is a third factor which tends to preserve the sanity and healthfulness of the race, and it consists in the fact that acquired defects and abnormalities are not transmitted to the children. For many years the Lamarckian view was held to a certain extent, at least, viz., that acquired traits could be transmitted. Weissmann propounded a theory that the germ cells which propagate the individual, are independent of the body cells which make up the structure of the system, and any injuries or diseases or defects which were inflicted upon the body cells, do not have any effect upon the heritage of the germ cells which live apart, and propagate only their own defects and virtues. This theory of Weissmann has been very much discussed, but it is now, I think, generally accepted. It is my experience that, in its general lines it represents, so far as human beings go, the truth.

* Read at the meeting of the Practitioners' Society, January 7th, 1910.

We know, for example, that if one were to cut off a leg of an individual for an indefinite number of successive generations, there would be no one-legged children born, and so far as mutilations affecting the human race are concerned, it is certainly an established fact that they are not transmitted.

In the same way, it is known that acquired diseases, like consumption, are not directly transmitted, or only in very rare instances. We would be able to say the same thing about vicious habits which have been acquired. A man of naturally good character and life, but who through the influence of bad associations, acquires the alcoholic habit, does not transmit this habit, and in the same way, there are certain "acquired" insanities, such as those following fevers or poisons, etc., the presence of which in an ancestry, so far as it is an insanity, need cause little apprehension on the part of the children. It is true, that if a parent has a disease which is injurious to his general health, which leads to bodily weakness, or by reason of which his tissues have become poisoned and enfeebled, the offspring may be made feebler, and, in this sense, the acquired enfeeblement of a parent may lead to a somewhat enfeebled descendant. But the special character of this trouble, whether it be drunkenness or vice or disease, is not thus passed on. In studying the statistics of insanity, therefore, with reference to its presence in the ancestors, we should take into account the fact that a certain number of these insanities are accidental, and have no direct influence in producing diseases in the offspring.

It has been found in recent studies of heredity, and particularly in the study of the development of monstrosities and freaks of various kinds, and even of idiocy, that serious effects upon the children can be produced by noxious influences that affect the mother during the time that the child is developing; that mechanical influences, like shocks, or chemical influences like poisons and infections, which get into the system at the time of pregnancy, may injure the vitality of the growing germ cells, and produce anomalies and monstrosities. By shaking and disturbing the contents of the fecundated egg in the chicken, all kinds of monstrous pullets can be brought forth.

Thus, you see Nature provides these three measures to lessen the injury that would come from the development of disease and bad habits in adult life; these three influences being (1) the tendency to sterility and extinction of degenerate families, (2) the tendency to bring the family back from the abnormal to the normal or average, through the agency of the ancestral "pull," and (3) the refusal, on the part of Nature, to transmit what has been acquired.—Medical Record.

DETERMINING THE HEIGHT OF AEROPLANES.

VARIOUS METHODS IN VOGUE.

BY COMMANDANT RENARD.

When the aeroplane first appeared, it seemed improbable that it would ever be capable of attaining a great height; when by chance it rose to a height of some twenty meters or so it seemed miraculous, and the anxious spectators held their breath for fear of a catastrophe.

But things have changed since that far-distant day

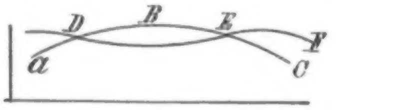


Fig. 1.

in 1908! On September 3rd, 1909, Morane reached 2,500 meters (8,202 feet). [This record has since been twice surpassed in the United States by the American aviators Johnstone and Drexel, who made world's records of 9,714 feet and 9,897 feet, respectively, as determined by the barograph.]

There are serious reasons for encouraging progress in this line in case aeroplanes are ever to cease being mere mediums of sport, and are made to give practical service either as a means of making extended journeys of for military reconnoitering.

The public interest in this question is shown by the prizes offered for altitude and the keenness of the competition for them.

In this article I will endeavor to describe the principal methods of determining the altitude attained.

In sporting affairs there are two demands—usually contradictory—to be satisfied.

For the comparison of records, and to establish indisputably the rights of each competitor, it is important that the results be determined with the utmost exactitude attainable. On the other hand, the public is eager to know results as soon as possible.

But precision is incompatible with rapidity. Calculation, to be accurate, requires leisure and absence of disturbing circumstances, and the public is impatient of the delay necessary for such computation. To satisfy the clamor of the crowd, approximate results must be given promptly, but it should be understood that such figures are subject to modification after careful verification.

The processes employed to determine the height of an aerial vehicle can be placed in two very distinct classes, according as measurements are made by instruments on board the airship or aeroplane, or by any

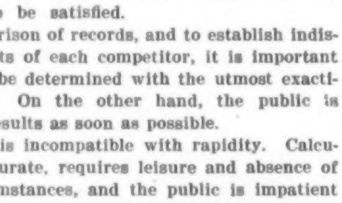


Fig. 2.

apparatus erected at a fixed point on the ground. To the first class belong barometric, optical, and acoustic processes.

THE BAROMETRIC METHOD OF DETERMINING ALTITUDE.

Balloonists usually employ the barometer, and nothing would seem simpler than to employ it likewise in the aeroplane. But this method is open to serious objections.

For one thing, the aneroid barometers used are not of irreproachable precision. They should always be regulated at the moment of departure, since all they denote is the difference of pressure between the point attained and the point of departure.

Besides, they have a common fault of retardation. This is because they do not indicate the pressure immediately, but only after a brief lapse of time. This retarding is more or less considerable according to the rapidity with which the altitude is attained and the pressure correspondingly modified.

If we represent by a curve *ABC* (Fig. 1) the actual pressure of the atmosphere, the barometer will mark the curve *DEF*, differing considerably.

These indications of the instrument approach the actual height in a variable degree, this degree being the more or less rapid according as the difference between the real pressure and the indication of the barometer is greater or less.

If the surrounding pressure is 20 millimeters less than that shown by the barometer, this will have a stronger tendency to gain equilibrium than if the difference is only 10 millimeters. From this observation the following conclusion may be deduced, viz., that the slope of the curve traced by the registering barometer is sensibly proportional to the difference between its indications and the real pressure.

In particular, when this slope is null, i. e., when the tangent of the curve traced is horizontal, as at *D*, the

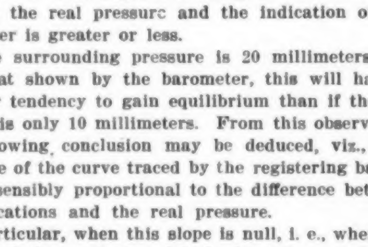


Fig. 3.

instrument has no reason to rise or fall, and consequently at that moment the indications correspond to reality.

Hence we conclude from such a curve, that at those points where its tangents are horizontal its indications are exact; outside these specific points, we can form only hypotheses.

In particular, it is impossible to know exactly the real height of maximum position, such as *B*, for the corresponding indication of the curve may be nearer or farther from actuality. Moreover, we may be certain that the maximum of the traced curve, as *E*, will always be lower than the real maximum attained.

In fine, the registering barometer, when properly regulated, always denotes altitudes more or less inferior to the actual ones attained.

It has been objected that the vibration of the motor affects the registering barometer on an aeroplane. But this, obviously, can be easily guarded against.

To this end, it seems, Latham hung the barometer around his neck. This plan might prove annoying, and can be avoided by suspending the instrument in a light cage of wicker or bamboo. In the current issue of the Scientific American a method of suspending by straps from the guy wires of an aeroplane is shown.

The eight corners of the parallelopipedonic box in which the instrument is contained are fastened by rubber bands to the corresponding corners of the cage. The barometer is thus as isolated as a spider in the center of its web.

This arrangement was made use of some twenty years ago by Col. Renard for sounding balloons, and he allowed instruments thus protected to fall 4 or 5 meters without the slightest injury.

THE OPTICAL METHOD.

This consists in sighting from the car by means of appropriate instruments an object of known dimensions, and thus measuring the apparent angle under which it is seen.

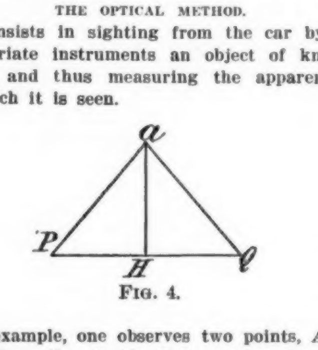


Fig. 4.

If, for example, one observes two points, *A* and *B* (Fig. 2), from the airship *N* by means of an instrument provided with a graduated scale, then the length *ab* read on the scale is evidently in inverse proportion to the distance *N A*, and can consequently give a positive measure of the height. But this process is applicable only when an observer is taken up for the sole purpose of making measurements, since the pilot is too much occupied to do so.

THE ACOUSTIC METHOD.

This consists in measuring the time necessary for sound to traverse the distance which separates the aviator from the ground. If on board an airship a note be blown on a powerful trumpet, the sound after being reflected from the ground returns to the aeronaut. If the time elapsed between the emission of the sound and the return of the echo be measured and multiplied by the speed of sound, the result obtained will be the double of the distance above ground.

This process also has the drawback of requiring a special operator. Moreover, since the speed of sound is about 340 meters per second, an error of one-fifth of a second gives 35 meters of possible error. The process also requires corrections for changes in the density of the air, and finally the results may be incorrect if there exist ascending or descending currents of air.

To sum up, the only reliable process in this class is the use of a registering barometer guarded against vibration, and it should be remembered that the

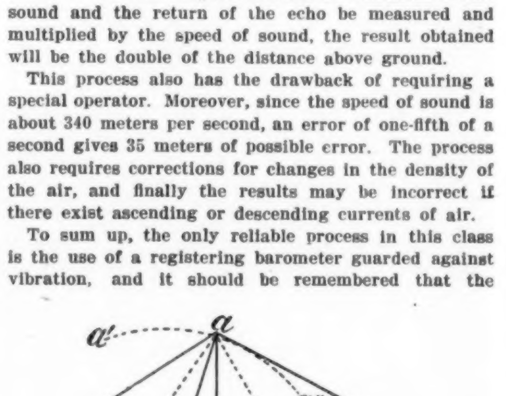


Fig. 5.

recorded height is always inferior to the actual. But if the maximum of the curve is very flat and gradual in its course, as in Fig. 3, there is strong probability that the difference is very slight; for in such a case the aeroplane will have maintained itself a long time at the same height, and the barometer will have gained a state of equilibrium so as to finally indicate the exact altitude.

DETERMINING HEIGHT BY OBSERVATION FROM THE GROUND.

The preceding will have convinced the reader of the necessity of terrestrial observations.

These are made exclusively by optical procedure. They all rest on a common principle, that of the resolution of a triangle part of whose elements are known—a problem familiar in elementary geometry.

Suppose an aeroplane started at A (Fig. 4). Two observers at P and Q sight it simultaneously. The distance PQ has been previously measured. By sighting, the angles APQ and AQP are obtained. The triangle is then determined, and with it the distances AP and AQ.

If the plane APQ was vertical, the height AH of

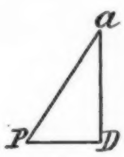


FIG. 6.

the triangle will be the distance sought. But this is not often the case.

To obtain the height another element is needed. The knowledge of the triangle APQ indicates merely that the position A of the aeroplane is found at a distance AH from the straight line PQ; but it can occupy any position, such as A' A'' (Fig. 5) on the circumference described with the point H as a center, and with AH as a radius in a plane perpendicular to the line PQ joining the positions of the two observers.

To determine precisely, therefore, the position of the point A, we need more information.

This can be obtained by sighting the aeroplane by a third observer at R. We then have a second triangle, AQR, of which the height will be AL; and the point A will be found equally in a circle having L for a center, AL for radius, and situated in a plane perpendicular to the straight line QR.

Its position in space will then be completely determined, and its height AD above the ground can be derived from the observations made.

We can also proceed otherwise. From one of the points P or Q—P, for example—at the same time we measure the angle APQ. We measure likewise the angle APD, comprised between the line of sight PA and its projection PD upon a horizontal plane.

This angle is nothing else than the apparent altitude of the aeroplane seen from the point P.

Knowing from the resolution of the triangle APQ the distance AP, and knowing the angle APD, we de-

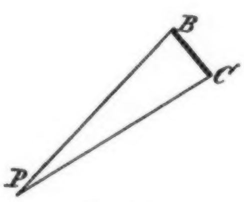


FIG. 7.

rive by a very simple diagram (Fig. 6) the height sought, AD.

The general defect in methods of this sort arises from the difficulty of making simultaneously the three observations required.

Hence ingenious methods have been devised for obviating or lessening this difficulty.

We will indicate three of these methods. They all have in common the measuring of the angle APD, i. e., of the apparent height of the aeroplane above the point of observation; but they differ in the mode of obtaining the length PA of the visual radius, i. e., the distance between the observer and the aeroplane. Moreover, the endeavor has been made to obtain this distance by a single sighting, so as to have only two observations to make instead of three.

The first method consists in determining the distance AP by means of an angle subtended by a straight line BC of known length forming part of the aeroplane or airship (Fig. 7).

It is evident that the smaller the angle BPC, the farther is the machine distant from an observer at P. One can therefore find the distance sought by means of suitable instruments.

This process is easily applicable for spherical balloons, whose diameter is known, and which under all conditions present an apparently identical contour. The contour is not the same for a dirigible or an aeroplane, for the slightest length BC may present itself more or less "shortened," and thus give fantastic results. Though we may avoid this difficulty by seeking to observe vertical lengths, such as the distance between the planes of a biplane, the method is wanting in the necessary precision.

Still another method has been employed at the camp of Châlons under Gen. Journée.

It consists in determining the distance sought, AP, by means of a telemeter.

The telemeter is an instrument with which, by means of an instantaneous observation, it is possible to obtain the distance of a sighted object.

It is based on the principle of the resolution of a triangle, one of whose sides is known (Fig. 4). But the base PQ which separates the two sighted distances is very short. These small dimensions facilitate the operation, but interfere with the exactitude of the result. This inconvenience is offset by measuring the two angles APQ and AQP with extreme precision. In this precision lies the whole value of a telemeter. In practice at Châlons the Souchier telemeter is used to measure the distance of the target.

It consists essentially of a metallic rule PQ (Fig. 8) about a meter long, and at the two extremities of which are two telescopes which, by means of proper reflectors, permit the observer, by looking into an eyepiece O in the center of the rule, to see the two images of the object simultaneously, as if he had an eye placed at each of the ends of the rule PQ. These two images are distinct, and thus the observer sees the object double, but by the proper adjustment of the instrument he can make the visual radii PA and QA coincide, and thus see the images superposed. The instrument is so arranged that the amount which it is necessary to incline the axis of one of the telescopes with relation to the other can be measured very exactly.

Hence one knows the angles APQ and AQP, and

FIG. 8.

consequently AP, the distance sought. As the base PQ is of fixed length, the instrument is so graduated that the distance sought may be read at once.

This method, therefore, reduces itself to measuring simultaneously by means of the telemeter the distance AP, and by means of another instrument (quite a variety of instruments can be used for this purpose) the apparent height of the aeroplane, i. e., the slant of the visual radius AP.

These two being given, the height AD can be obtained by the construction indicated in Fig. 6.

Though the number of observations is thus reduced to two, and the two observers placed side by side, it might be feared that the readings were not simultaneous.

To avoid errors from this cause, the two observers may be left free, each to act for himself, but on condition of noting exactly the time of the observation.

If, for example, the distances have been measured by the telemeter at 11:1:15, at 11:1:30, etc., we trace according to AB (Fig. 9) the curve of the distances observed at each instant, a curve in which the points CDE are exactly determined.

Supposing that another observer has measured the height at 11:1:5, 11:1:20, 11:1:36, etc. We trace on the same chart the curve FG, the curve of apparent heights observed, and in which the points H, I, K are also exactly determined.

We shall not have made at any given moment simultaneous observations of distances and height; but the continuity of the curves being given, we must admit that at any moment—at 11:1:10, for example—the apparent height corresponds to the point L, and the distance to the point M.

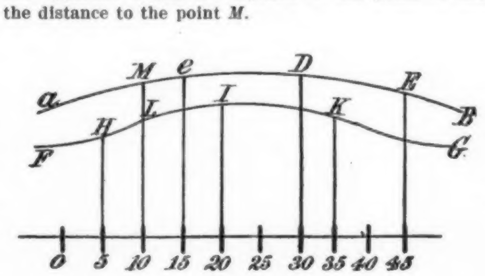


FIG. 9.

We can therefore obtain the real height above the point sighted at that moment, and we can do this for any moment, which permits us to obtain the maximum height.

This process, applied with care, gives results worthy of confidence; but unfortunately the necessary instruments and trained observers are not always at hand. Hence it will be of interest to describe another method which may be improvised anywhere, and made use of by intelligent though untrained observers.

Two observers are stationed at PQ (Fig. 10). The distance PQ is known, and it is known beforehand that the aeroplane must pass vertically above a point intermediate between P and Q.

The two observers are provided with instruments for measuring apparent height. These may be very simple. Poles graduated in meters and fractions and erected vertically at BC and DE, at known distances, BP and DQ, from the observers, will suffice.

It is indispensable that the points BP and DQ should be in the same straight line.*

The office of the observers is to read upon the poles nearest them, when they see the aeroplane cross the line, the height at which it seems to pass. This in-

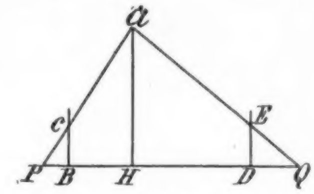


FIG. 10.

formation and the knowledge of the distance PQ previously measured suffice to obtain the height sought.

Suppose that an aeroplane is at the point A. The height to be measured is AH. The visual radius from P to the aeroplane cuts the pole B at the point C, as the radius QA cuts at E the pole D.

The heights BC and DE have been measured by the observers, and the right-angled triangles similar to those of Fig. 6 give us the following proportions:

$$\frac{PB}{CB} = \frac{PH}{AH}$$

and

$$\frac{QD}{ED} = \frac{QH}{AH}$$

Adding these two equations, we have

$$\frac{PB}{CB} + \frac{QD}{ED} = \frac{PH + QH}{AH} = \frac{PQ}{AH}$$

In this formula the lengths PB, QD, and PQ are known (having been measured in advance), the lengths CB and ED result from the observations made, and AH is the height sought, which can be easily calculated.

Thanks to an abacus devised by Com. Ferrus and Capt. Raguet, the real height can be known at once, knowing the two apparent heights and the distance of the two stations.

It should be remarked that the result is independent of the length of the horizontal distances HP and HQ.

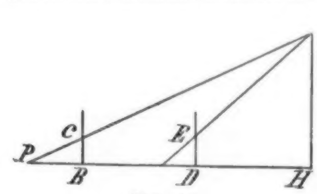


FIG. 11.

In other words, the aeroplane may be more or less near one of the two observers, without the measurement being interfered with, provided the apparent height can be measured.

Since, in practice, the two observers are separated by several hundred meters, while they are only a few meters distant from the poles, the aeroplane has a large space at its disposal.

Moreover, by slightly modifying the method, it may be used even in case the aeroplane passes outside the line PQ (Fig. 11), though then, of course, the application will be less precise.

This method has the advantage of demanding neither trained observers nor special instruments. Also it assumes indisputably simultaneous observations.

On the other hand, it can be applied only at the moment when the aeroplane crosses the line between the two observers.

It gives the altitude at a determined point, but not necessarily the greatest altitude.

To sum up, I advise the use of the registering barometer, properly suspended, to give the general course of the curve of altitude; and as a means of exact determination, either the Châlons method by telemeter and measurement of apparent height, or the process of two observers sighting simultaneously the aeroplane at the moment it passes within their alignment.

* In aerodromes, an instrument called a sitometer, designed by Art. Capt. Raguet, for measuring apparent heights, is commonly employed for this purpose.

THE PHYSIOLOGY OF LIGHT.—II.*

SOME OF LIGHT'S OCULAR EFFECTS.

BY CHARLES PROTEUS STEINMETZ.

Concluded from Supplement No. 1824, page 391.

Ultra-violet radiation of medium frequency, that is, of considerable harmfulness, is also produced by spark discharges, and by vacuum discharges in the Geisler tube, and it is quite possible the Geisler tube discharges may give even these extremely high frequency, extremely destructive radiations, the same as the low temperature mercury arc. Since the vacuum discharge is always operated in a glass envelop, you do not get this high frequency of ultra-violet light outside, but if anybody desires to experiment with a vacuum discharge in quartz tubes he should be extremely careful.

Incidentally, the characteristic of these most destructive high frequencies of radiation is that they produce ozone from the air, and they can, therefore, be recognized by the odor of ozone. A low temperature mercury arc in a quartz tube causes a very intense smell of ozone which it produces. So, wherever you have any kind of radiation giving the ozone smell to an appreciable extent, it is safe to be extremely careful. It is not a sufficient characteristic in many cases, because ozone is also produced by high electrostatic voltages, and where, therefore, high voltage electro-static fields are used, as, for instance, in Geisler discharges, ozone may be produced by them, and the presence of ozone is not a sufficient criterion, but the radiation in such cases may be harmless, because it is not the radiation, but the electro-static field which produces the ozone. Where, however, in a low voltage circuit, you get a radiation that produces ozone you may know it will be destructive very rapidly. Possibly the extreme destructiveness may be the same effect which produces ozone, that is, it causes resonance vibration of the oxygen atoms, and thereby dissociates and destroys living tissue. In the middle range of the ultra-violet radiation, we have as characteristic distinction that the mineral willemite, the native zinc silicate, fluoresces bright green; it does not fluoresce in the blue or violet, and it does not fluoresce in the long ultra-violet light waves, that is, waves which are nearer to the visible light, and relatively harmless. Wherever you see the green fluorescence of willemite you know that you have ultra-violet radiation of sufficiently high frequency and sufficiently short wave length to be dangerous.

I mentioned that glass is perfectly opaque to this radiation. A very high frequency or a medium frequency ultra-violet radiation cannot penetrate glass, and glass therefore affords as far as I know a practically perfect protection against harmful ultra-violet light. Glass is not quite opaque to the longest ultra-violet waves, but probably for about one-quarter of an octave beyond the visible ultra-violet light, the light penetrates glass to a certain extent. This ultra-violet light of longest wave length does not produce the characteristic fluorescence of willemite, and is very little harmful. Excessive intensity and exposure for a long time is indeed harmful, and causes ultra-violet burns, but any moderate intensity, as we meet in artificial illuminants, and more so still in daylight, is harmless.

You see we have in the ultra-violet light a very wide range of radiation in which the danger increases from practically nothing, at the upper range of wave length, to an extreme destructiveness at the highest frequency. We have glass as a practically perfect protection against the more harmful rays, the characteristic of which ray is the green fluorescence of willemite. It does not occur in the long wave ultra-violet light, where the glass is transparent. Where, therefore, you have to deal with arc and spark discharges, as at wireless telegraph apparatus, etc., it is necessary, for protection, to inclose the source of light in glass. In that case, however, you must realize it is not sufficient to merely interpose a glass plate, because you still get reflected light, and reflected ultra-violet light is also harmful; you must inclose the source of light entirely by glass, otherwise, probably in a reduced degree, but still quite marked, you get the harmful effect of ultra-violet light. Wearing glasses affords considerable protection, but not absolute protection, because enough stray light comes in so that you will notice it, as I noticed when I looked at a low temperature quartz mercury lamp for a few minutes. The other gentleman who looked at it without glasses is not quite well yet, and that was eight years ago.

So far we have discussed the specific physiological effect of radiation on the eye, more particularly the harmful effect. There are, however, effects not only on the eye as an organ, which is made to notice radiation, but on the living organisms in general. Radiation exerts a powerful effect on living protoplasm, on animal and vegetable life. The most important effect of radiation is undoubtedly that on plant life. All the energy of plant life is derived from the energy of radiation of sunlight; that is, the chemical energy which is stored in the products of plant life is derived from the radiation energy of the sun's rays, and the radiations which do the chemical work on the plant are the long waves of the red and orange and yellow. They are the actinic rays of plant life, while the green and blue are non-actinic rays. If in general we speak of the blue and violet rays as actinic, and of the red rays as non-actinic, it is merely because it happened to be so with the first substance on which we observed the chemical action of radiation, namely, silver salts, which react on the short radiations. The chemical action of radiation is undoubtedly some kind of a resonance effect. It is not simply resonance of the atoms, because if this were the case it would be responsive to a definite frequency, while the chemical compound responds to a wide range of frequency; but it must be some more complicated form of resonance, as there is a relation between the mass of the resonating chemical element and the frequency. We find that the relatively heavy silver atom—atomic weight 108—responds to the shortest visible rays, and the invisible ultra-violet rays; that is, the maximum actinic power for silver compounds probably is at the end of the violet, or beginning of the ultra-violet. The much smaller oxygen atom—weight 16—does not respond to these radiations, but responds to the extreme end of the ultra-violet, about one or two octaves higher: a higher frequency, as would be expected, is the resonance frequency. On the other side, when we come to the much heavier complex carbon radicles of the organic compounds of plant life, you see we must expect them to respond or resonate with lower frequencies than even the silver atom, and so we find that plant life is responsive to the extreme end of the long waves of the spectrum, to the red and orange and yellow.

The chemical action of plant life depends on the green substance which exists in the leaves and young stems, chlorophyl. It absorbs red and yellow radiation and converts the energy into chemical energy, which it uses by splitting carbon dioxide CO_2, rejecting the oxygen, exhausting it, and using the carbon in building up the complex structure of the plant—in what manner we do not know, but suspect that formaldehyde COH_2 is the intermediary product, that is, that the first action of radiation energy is exerted upon carbon dioxide and water, and causes the CO_2 and H_2O to form formaldehyde COH_2 and oxygen O_2. Whatever it may be, does not interest us at present, the interesting feature is that the chemical action, on which plant life depends, receives its energy from solar radiation, from the long waves of the spectrum, while the shorter waves of green and blue, as non-actinic, are rejected: therefore the green color of plants. Ultra-violet light again is harmful. As we may expect, the frequency is so short, that heavy groups of carbon atoms cannot respond to it, but the individual atoms may respond and may cause dissociation, that is, death, while it is the rearrangement of the atomic groups which we call life.

The plant life, therefore, is synthetic or constructive. From simple compounds, carbon dioxide, water, etc., and by the energy of radiation, the plant builds up chemical compounds and stores the energy of the radiation as chemical energy. Inversely, then, animal life and also our own, is analytic or destructive. We cannot directly derive the energy of our life from radiation power, but derive it indirectly as the chemical energy which the plant has stored. Thus ultimately, we also depend for the energy of our life on solar radiation, which has been converted into chemical energy, stored as such in the plant, and then is used by us, by converting the chemical energy by combustion in our bodies into other forms of energy. Undoubtedly, this is the most important physiological effect of radiation, that exerted on the plant, as all life depends on it. The animal kingdom can not utilize the energy of radiation. Nevertheless, radiation exerts a physiological effect also on the animal or human body when impinging on it. The effect is the same as that of any powerful agent: it is stimulating when of moderate intensity, and destructive when of high intensity. The stimulating effect may be used therapeutically to a certain extent, and is being used as a convenient method, especially in cases where the metabolism is sluggish, to increase rapidity of circulation, similar in effect as the static field, for instance. Thus radiation power, or light, has a decided stimulating effect on man, when of moderate intensity, while excessive intensity causes harm; excessive exposure to sunlight we know causes sunburn which, when severe, leads to the destruction of the surface tissue of the body which has been exposed. We also find the same effect as we notice with any powerful drug: frequent exposure for increasing duration gradually produces acclimatization also against the solar radiation so that we can stand intensities of radiation without any harm which would ordinarily produce severe sunburn. Going still further, those races which have been developed in tropical climates have acquired during the ages of their development a protection against solar radiation by pigmentation of the skin, the negroes. They can stand amounts of solar radiation which would be fatal to a white man. Here is a permanent acclimatization acquired through the ages, the same as we acquire temporary acclimatization by exposure to sunlight. However, in general the body is fairly resistant to radiation—man can stand without harmful effect radiations of considerable intensity, probably by being acclimatized to it, by having lived as day animals, and developed through the ages, exposed to solar radiation: after all, counting the history of the human race, it is only a short time since we have been protecting ourselves by clothing against sunlight, but we had a chance to become acclimatized through untold thousands of years. So we still have the advantage of this acclimatization to radiation energy.

The effect of radiation on lower organisms, micro-organisms, is very interesting. Many micro-organisms, germs, live in the light. They can stand a considerable amount of light, though possibly direct sunlight may kill them. A moderate intensity of light, diffused daylight, does not harm them, but is necessary, and when they are brought into the dark they either die or cannot multiply. There are other germs which are used to live in the dark, and are killed by light. Thus micro-organisms which have been developed in light, require light, and are killed by darkness, and micro-organisms which have been developed in the darkness are killed by light. Thus among the putrefactive bacilli—germs of decay—there are those which require light and air and those which live in darkness, and would be destroyed by daylight. Especially is the latter the case with the disease germs, which live in the interior of the body, in darkness. They therefore are used to the dark, and light is fatal to them. As a result disease germs are more or less rapidly killed by light, and especially direct sunlight is one of the most powerful germicides and disinfectants. The power of resistance of different bacilli against sunlight is different. Those micro-organisms which can live outside the human body, in the soil for instance, as the anthrax bacillus, can stand a much greater intensity of radiation or light than those which cannot live outside the human body, as, for instance, is the case with the disease of civilization—tuberculosis. The tuberculosis bacillus is especially sensitive to light and is almost instantly killed by direct sunlight. The greatest prophylactic method, therefore, is to flood our homes with light—instead of that we do exactly the opposite. We very carefully exclude sunlight, to keep the carpets from fading. Direct sunlight is the most powerful germ destroyer.

As light destroys pathogenic germs, disease germs, it is important to consider its application as a therapeutic agent in combating these germs in the human body. In this case, the medicinal use of radiation for combating infectious diseases, the action necessarily must be a differential effect, that is, we depend on the radiation being sufficiently intense to kill the disease germs in the human body, or at least weaken them sufficiently so that the white blood corpuscles can eat them up, while at the same time the radiation must not be powerful enough to kill the cells of the living tissue, but merely stimulate them, so increasing their ability to fight the disease germs. Therefore, in surface infections, as tuberculosis of the skin (scrofulosis, lupus), light has become a very powerful thera-

* Read before the Engineers' Club of Philadelphia.

peutic agent and is the most efficient method of cure. When you come to deeper seated infections, you see the difficulties become very much greater, because the tissue of the human body is nearly opaque to radiations, especially ultra-violet radiation, which are the most powerful destroyers of germ life, and we can not get a sufficient intensity of radiation far enough down into the body, without destroying the surface tissue. We can only attack those germs efficiently which are near enough to the surface to be reached by radiation of sufficiently moderate intensity not to destroy the tissue of the body. We naturally think of X-rays as radiations which penetrate through the body, and for deep-seated affections they are used and have a beneficial effect. We must realize, however, that they are already so far in frequency from the visible light, the solar radiation, that the acclimatization which the human body has acquired against solar radiation does not exist to the same extent against these very much higher frequency X-rays, that is, the difference of sensitivity of disease germs and of the cells of the human body to X-rays is much less than for long ultra-violet rays, and therefore, the range wherein we can kill the germs without harming the patient is very much narrower, and the conditions very much more risky than when using the long ultra-violet waves.

DISCIPLINE AND EFFICIENCY.

THE RULING OF GREAT ORGANIZATIONS.

BY HARRINGTON EMERSON.

The institution built up on time schedules has become mightier than the man and the man is immensely benefited by the discipline of the institution.

Thirty years ago along the great inland rivers of the United States, the Ohio, the Mississippi, the Missouri, the greatest difference was apparent between the river towns and the railroad towns. In the river towns steamboat passengers were quite content to wait several days, idling on the levee, whittling or swapping yarns or doing the *dolce far niente* on the hotel piazzas. When far up or down the river the deep bellow of the boat's whistle was heard, day or night, the sleepy town awakened into prodigious and spasmodic activity until the boat had come and gone; then it went to sleep again. Clocks were not needed and all business was conducted on the same easy lines. Notes were paid, not when they were due, but when the crops were marketed. An Eskimo who figures years as so many snows, months as so many moons, and days as so many sleeps, would have found the business methods of the steamboat town wholly normal—steamboat coming down the river, great excitement; whale seen in the offing, great excitement—what was the difference? In the railroad towns there was a very different spirit. People had clocks in their houses and watches in their pockets; they went to the railroad station on railroad schedule time; the coming and going of the daily trains became definite, regulating and educational events even to those who never traveled; they got into the habit of keeping other appointments; they were beginning to learn that the institution was greater than the individual.

The near discipline of the rich man who makes his servants await his convenience in spite of a definite programme arranged by himself, the near discipline of some railroad magnates who more or less disarrange the train dispatching on a whole system by their lack of observance of their own special train schedule, the near-discipline that would bend the sublime order of the universe to individual dilatoriness as in the story of Joshua's command to the sun to stand still, is not what is meant by "Discipline" as an efficiency principle.

There is the discipline of life which leads us, almost compels us, to follow the teaching that comes to us from intimate contact with the existing order. "The wicked shall not live half their days." It is easier to learn to fly than to make a landing. In a narrower sense we speak of the discipline of St. Francis, of St. Dominic, of Ignatius Loyola, meaning not punishment, but a definite, regulated life, conduct, and observances. In the narrowest sense we use the word to denote the act of punishment inflicted on a bad boy with the object of encouraging observance of prescribed conduct or rules.

The word discipline thus has three—if not more—meanings.

Adam began to experience the discipline of life when Eve became his daily companion; discipline and the greater life began in earnest for both of them when they found themselves outside the gates, with Cain, Abel and Seth frisking around, for there is no such categorical imperative as the sharp outcry of a very young baby. Adam and Eve, owing to lack of experience and overvaluation, spoiled Cain; so being undisciplined, his exaggerated personality could not brook the preference shown Abel and he murdered him.

Discipline as an efficiency principle includes all meanings from lessons of life to man-inflicted punishment. The greatest regulator of conduct is the spirit of the organization.

Because the success of the whole plant depends not on its wealth, or its men, or its product, but on its spirit and rule, penalties for persistent infraction should be relentlessly severe. A whole race is exterminated in Africa because through ignorance it braves the bites of the tse-tse fly. If we fall asleep in charcoal fumes we do not awake, if we touch hot iron we are burned, if we put our heads under water for five minutes we drown, if we touch through mistake a live high-voltage wire, the penalty may be instant death. There are no rules and regulations about these punishments, they need no rules and regulations.

The old story runs that Eve and Adam were banished from Paradise for eating a forbidden apple and that all their descendants not only cannot get back except by very special favor, but will have to spend all eternity in hell. Cain's punishment was also exclusion; he became a fugitive and a vagabond, he was not to be rewarded for his work and he bitterly complained that his punishment was greater than he could bear. One Cook wrote a cheerful book about scaling Mount Bulshaio and later sent some thrilling messages about the North Pole. Not because Peary accused him, which most people resented, but because his own stories and acts proved him a liar, he had to flee, like Cain, into obscurity and oblivion although no man pursued.

Enforced resignation is one of the severest penalties in the army and navy; on a great railroad in the middle West employees were rarely discharged; they worked themselves up or down by an automatic system of merit and demerit marks. In another great American business, a large specialty store, the making and enforcement of rules is turned over to a committee of the employees. It is a universal experience that no judge is as severe and unrelenting as the more righteous contemporary with the same temptations and opportunities. It is not the child, the man, or the older woman who condemns Magdalen. It is not the child who pities the playmate killed by carelessness, it is not the successful old man who pities the gray-bearded derelict who has made a general shipwreck of life.

If the spirit of the plant does not drive an undesirable associate away, if standard operation and standard practice, both of which affect conduct, if reliable, immediate and adequate records, if absence of efficiency reward do not automatically, effectually and peaceably eliminate the undesirable, it is time for the strong hand to descend.

Under the best management there are scarcely any rules and there are fewer punishments. There are standard-practice instructions so that every one may know what his part in the game is, there is definite responsibility, there are reliable, immediate and adequate records of everything of importance, there are standardized conditions and standardized operations and there are efficiency rewards.

There can be organization without discipline, as in all plant life; there can be discipline without organization, as in most animal life. Because man has supernal ideals; because the progress of centuries can be lost in a year, in a minute, even (as during an earthquake) if organization is weakened—the devil indeed catching the hindmost; because our unstable human organizations, even the integrity of the family, depend on discipline, it becomes a fundamental efficiency principle which continuously, vigorously, never falteringly enforces a series of standards of high individual or combined conduct.

"He that ruleth his spirit is better than he who taketh a city." Discipline is not arbitrary rules with punishment for short-comings real or imaginary.

The tremendous simplicity of the scheme of the universe is the real marvel of it all. Universal attraction and universal repulsion—all elements have approximately the same atomic heat—but three principles underlie all life—self-preservation, race-perpetuation and the proprietary instinct. From a few elementary laws, other universal laws spring; and any near-law that cannot trace its parentage straight back to one of the supernal laws, if indeed there is ultimately more than one supernal, is probably not even a legitimate near-law.

Fine manifestations of disciplined performance are the four eighteen-hour trains each day between New York and Chicago. So unobtrusive is the perfect discipline that the passenger sees no rules or orders given, he does not see the far ahead light or semaphore signals that govern progress, he sees still less the telegraphic messages flashed by the dispatchers to the signal towers, he knows little of the duplicate orders issued to conductor and engineer. The discipline is that of the velvet paw armed with the sharpest claws, infraction possibly resulting in destruction of the whole train, a trans-human punishment; infraction, even if there is no immediate disaster, resulting in reprimand or dismissal.

So great is inefficiency of all kinds everywhere that the application of even this one principle of discipline has produced great results through military or church organizations. Just as soon as a community bends to discipline, whether its members are followers of Romulus, of Leonidas, empires are either founded or shattered, and just a little discipline as to dress and work have made such American communities as the Shakers, Economites, Mennonites, wealthy. In the army, as in the church, the first vow is obedience; and in Schiller's ballad the slaying of the dragon did not save St. George from condemnation and punishment for his disobedience. The large office buildings in New York are peculiarly dependent on discipline. They are miniature cities in which all municipal activities, lighting, heating, cleaning, transportation, are constantly going on. As long as the tenants are present from 8 A. M. to 5 P. M. high order is maintained, but shortly after 5 o'clock discipline relaxes, attendants raise their voices, begin to smoke cigarettes, to romp, and the conviction grows that if these modern palaces were turned over as a possession to their own trained attendants, in an incredibly few weeks they would be marred and scarred, dirty and disorderly, physically and morally.

I have been asked why "co-operation" was not to be considered as one of the basic principles of efficiency. Common ideals striven for by a disciplined organization, supernal common-sense which forgets the little for the sake of the larger achievements, necessarily result in co-operation, even as the bees, having accumulated a full store of honey, seem to obey a queen, who "as it happened with many a chief among men, appearing to give orders, is himself obliged to obey commands, far more mysterious than those he issues to his subordinates." The fundamentals of discipline are in fact better learned from the government of a beehive than from college courses, from armies, or from any industrial organization. No bee appears to obey any other bee, no bee seems consciously to co-operate with any other bee, yet so perfect is the "spirit of the hive" that every bee engrossed in her special task, fatalistically acts on the instinct that all other working bees are also as busy for the common good, and when the drones fail to be useful the working bees become consciously indignant and make away with them. Co-operation is a matter of course, not a virtue; its absence is the crime.

Supernal discipline is inspired by a greater emotion than fear.

The time to inspect boiler sheets is before they are made up into steam boilers; the time to inspect anchor chains is in the making, not when the great steamer is straining with broken machinery to the windward of the Scilly Islands in a midwinter storm. In all industrial life everything is tested, materials, design, except the all-important men. In the little shop, rigidity of human inspection is high, the master looks over each man, has probably watched him for months or years before engaging him; but in the large shop, where the personal inspection of master has become impossible, even the most elementary safeguards are thrown to the winds and men are absorbed with less discrimination than the furnace under the boiler absorbs air.

No man enters West Point without passing severe elementary examinations. It is a tremendous privilege to be admitted, a disaster to be excluded. There ought to be a high membership ideal for every plant,

no newcomer admitted who was not fit in every way, no man cut off except for cause. Discipline begins before the applicant is taken on. Nine-tenths of all the harder discipline ought to be applied to exclude undesirables, men who by reason of bad character, bad and offensive habits, destructive tendencies, laziness or other faults, are unfit to become working members of a high-class organization. It is before he is admitted that the applicant should hear of the ideals of the business, of its organization, of its methods.

In railroading, why should each conductor and engineer be compelled to secure a watch of the best grade, why should this watch be periodically inspected, yet the future conductors and engineers be recruited in the most haphazard fashion? There is scarcely any greater or crueler injustice to a boy or to a young man than to allow him to enter on a career for which any competent examining committee would tell him he was unfit, there being other careers for which he is better adapted.

In coal mining seams of coal with bands of slate, clay, or dirt are not mined, or the coal is carefully picked over, or washed; in lumbering all material is graded, millions of feet of inferior grade being burned; in wheat raising the farmer strives to attain grade; standards are devised and rigidly adhered to in the live-stock markets; but a company building cars or running a factory or mining coal will engage and employ almost anyone that applies for work, who is not under age, over age, or absolutely crippled.

The master organizer, whether saint or assassin, does not admit those who would make trouble and thus avoids nine-tenths of possible insurrection; the master organizer creates a collective spirit that prevents another nine-tenths of disciplinary troubles, a dependent sequence that brings his remnant of insubordination down to one per cent of the usual and possible and with this one per cent of remnant he easily deals.

As I write, the morning papers contain three items. "Manchester, England; The Federation of Master Cotton Spinners has locked out 130,000 men. Berlin, Germany; Negotiations with the object of preventing a lockout of the metal workers have failed. Nearly 100,000 men are affected in Berlin alone, it is estimated that at least 500,000 throughout Germany will be turned out. Paris, France; 80,000 strikers tie up railroads. Entire country may soon be involved."

Whatever the merits of the cases, it is safe to say that most, if not all, the principles of efficiency were flagrantly absent in these three great disputes. In the case of the cotton spinners the story runs that a worker was discharged by a foreman because he objected that certain assigned work was not in his line. Ought it to be possible for two men in the bottom ranks of a great business to bring on a strife involving 130,000? Were his duties made clear to the worker before he entered the company's employ? Ought the foreman to have had the power to discharge him for an objection, on its face, entirely reasonable and sustained by his fellow workers? In this dispute we have the old-type, arbitrary, anarchical organization of both masters and men. We find first of all defective discipline, rejection of competent conciliatory counsel, painful absence of common sense, and no high ideals.

Under efficiency principles there would have been staff advisers to invent and build up safeguards against catastrophes of this nature, just as levees are built along the banks of rivers inclined to flood. Trouble-making men, whether workers or foremen, could neither have gone on the payroll nor have stayed on it. There would have been staff conciliators whose business it would be to take in hand incipient emotional flames and smother them before they grew into great conflagrations.

The principles of efficiency are not vague platitudes; they are intensely practical remedies, tested, tried out, and successful in preventing wastes, preventing the losses caused the State and community by the cessation of labor of hundreds of thousands of men, preventing the greater misery and suffering due to the enforced idleness of heads of families. While master and man quarrel and bicker, the State suffers and women and children pay the penalty. Socialism gains recruits not from the arguments of its advocates, since no human being is naturally a socialist, but from the unendurable shortsightedness and shorter temper of individualistic men.

It is not enough for the owners to have ideals; they must be transmitted to the employee, and nothing is easier, as any one who has studied the psychology of crowds knows; but it is idle to expect the average worker to rise above the spirit of the place he works in. If it is untidy, disorderly, filthy, if the accommodations for his necessities are lacking or vile—imposing steel and concrete construction, saw-tooth lighting, compound condensing engines, and all the over-equipment to which in the past we have pinned our faith, will not inspire the worker.

On one occasion, beginning an investigation of a great machine shop employing one thousand men, I went the first morning at half past 6 to the power house. It was a dark day early in February, temperature 8 degrees below zero and the shops were none too comfortable. When the whistle blew at 7 o'clock I watched the ammeter line. The power consumption rose instantly to what proved to be the average maximum and it stayed up. I returned at 11:30 and watched the ammeter line stay up until 11:57, at which time the record, reliable, immediate, and adequate, began to round off, suddenly dropping as the noon whistle blew. It came up again at 1 o'clock and stayed up until 6 o'clock. The two parallelograms were very different from the flattened records, shaped like half ellipses, so usual in similar shops. It was evident that the superintendent was a man of discipline, and the opinion I formed in that forenoon of his ability was confirmed by three years' intimate association. It was his practice to enter the shop at 6:30 A. M. to stay until after 6 P. M., and I heard him severely reprimand a foreman for allowing the superintendent's father, a worker in the shop, to take off his overalls five minutes before closing time. Men worked enthusiastically, loyally, and reliably for this master of men.

The way to guard against trouble is to make the position desired by a superior man, to allow it to be filled only by a superior man, to maintain the position at a high level. If the owners and managers of a plant of any kind are orderly, enthusiastic, loyal to the work, punctual, courteous, decent, competent; if they feel their obligations toward those they direct; if they are honest, economical, diligent and sound in health, they can well demand similar qualities in all the employees. I have placed order first, believing in the spirit of the proverb that order is nature's first law and also the remark which Goethe puts into the mouth of Mephistopheles: "Make use of time, it is so fleeting, but order saves time." No man ought to be allowed to enlist who cannot start in with order, enthusiasm, loyalty, reliability, who is not courteous and decent; no man ought to expect to stay who is not competent, a good brainworker, honest, economical and diligent. If in addition he has good health, so much the better.

The self-executing discipline that is worthy to be an efficiency principle is the allegiance to and observance of all the other eleven principles, so that the twelve principles do not become twelve rules unrelated to each other; they do not become separate and easily dislodged rails of a fence, which is more an indication of boundary than a barrier; they do not even become the iron palings of a French fence, whose spacings as a boy I had carefully tested by my head, knowing that where this member could pass my body could slip through—much beloved interstices, an ever ready path to safety when pursued by outraged minions of the law or exasperated householders or other representatives of the established order against which I was in perennial rebellion. As promoters of observance of arbitrary rules to which as a free American boy I had not given my assent, these elaborate fences were joyful failures.

It is otherwise with the rabbit-proof, dog-proof, hog-proof, bull-proof, wire-netting fence whose meshes cannot be squeezed apart, whose barbs punish familiarity, which is strong enough to kill outright an animal running diagonally against it.

The principles of efficiency are the strands of a net each interwoven with the other so that in reality the first study of any organization is to find out to what extent common-sense, competent counsel, discipline, and the other eight principles have been applied to the first principle, "Ideals;" to find to what extent ideals, competent counsel, and discipline, have been applied to common-sense; to find to what extent ideals, common-sense, competent counsel, have been applied to discipline. Any system or act of discipline that cannot pass the test of each of the other eleven principles is near-discipline, not supernal discipline—is a remnant of arbitrary individualism, the first misstep in an anarchy that will extend all the way down the line.

No efficiency principle stands alone, each supports and strengthens all the rest, each is supported and strengthened by the other eleven. They are not as mutually interdependent as the stones of an arch, each a key stone which if removed brings about the collapse of all the others; they are more like the stones of a dome, any one of which can be taken out, leaving a weakened, but not a destroyed structure.—Abstracted from an article published in the Engineering Magazine.

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